MECHANICAL HARVESTING and RIBBONING OF RAMIE FIBER

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MECHANICAL HARVESTING and RIBBONING OF RAMIE FIBER

By

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Ramie, a bast fiber, has been known and produced since historical times as a superior textile fiber. During most of its known history, ramie has been produced by hand from small family plots in oriental countries. Much of the fiber has been spun and used locally. However, hand-cleaned ramie referred to as "China grass" has long been known in commercial channels and spun and woven in many places in Europe.

As a commercial crop, ramie was not introduced into the United States until 1855. And the problem of extracting the fiber was so difficult that little attention was paid to production (*5*).[2]

Ramie fibers consist of the fibrous inner bark of stems of *Boehmeria nivea*. The individual fiber cells are cemented together by gums, waxes, and pectins, which constitute the bast layer. Before it can be used for textile purposes, this layer must first be removed from the woody stem and then further processed to remove certain of the cementing elements.

In common usage the first process is referred to as decorticating and the second as degumming. The degumming process usually is the spinner's problem. However, a large producer may have an overall organization capable of supplying anything from decorticated fiber to custom stapled and degummed material for many purposes.

In general, European spinners prefer undegummed fiber. They have used China grass from the Orient for many years and have their own degumming processes and machinery. American spinners, on the other hand, prefer degummed and stapled fiber for spinning either alone or in blends with other fibers.

RAMIE CULTIVATION

Ramie is planted by root cuttings in rows. On well-prepared fertile fields the plants soon cover the ground with a solid mat of vegetation from which several cuttings per year can be made. No replanting is required for a number of years, usually 8 to 12 or even longer under some cultural practices.

Early in the spring the winter growth, which has no value for fiber, is cut back with a mowing machine. This cuts down useless winter growth and stages the fields for scheduled harvesting during the growing season. Harvesting at 60-day intervals is normal, with three and sometimes four harvests per growing season (*4*).

At maturity all harvestable stalks will be approximately the same age and height but will vary somewhat in diameter, and they will have leaves only near the tip. The stalks will have no lateral branches in fields that have the normal number of stalks per square foot. After staging or cutting, only stalks that get a good early start will reach maturity. Later sprouts will be shaded by early ones; they will not be able to compete and will either die or make only poor growth. Cutting should not be delayed after maturity as second-growth sprouts will come from the roots.

Fields of healthy, well-managed ramie will be of even height, varying from season to season and from harvest to harvest but uniform over any given field. This is a great advantage in harvesting. Figure 1 shows a field of ramie.

Chemical defoliation by airplane to remove top leaves is a common practice in south Florida and

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[2] Italic numbers in parentheses refer to Literature Cited, p. 26.

FIGURE 1.—A field of ramie.

elsewhere (*1*). Careful timing is necessary since delay in harvesting after defoliation permits sunlight to reach the root area and encourages second growth and lateral branching.

THE RIBBONING PROCESS

The term "decorticating" in common usage applicable to ramie means stripping off the bark or outer coat of the freshly harvested crop. Most machines designated decorticators also do some cleaning and produce a fiber that is free of wood, bark, and sufficient gums and pectins to permit separation of the fiber. In practice, however, a wide variation of clening results from various decorticators.

The terms "ribboning" and "decorticating" are really degrees of the same thing (*6*). In its simplest form, ribboning consists of removing the inner woody core from the stems. With ramie and some other fibers it is possible to remove the outer bast layer in one long flat ribbonlike piece.

In practice few machines or processes produce an intact ribbon; most do some additional scraping or working, which separates the fibers and removes some of the gums and pectins. Hence, by degrees ribboning becomes decorticating with no clear-cut division between processes.

This publication is concerned only with ribboning, but it should be understood that as refinements are added, the process approaches decortication and may produce fiber as readily acceptable as decorticated material.

MACHINERY

Machines for Ribboning

Machines for ribboning can and do vary greatly in complexity, and more importantly, in capacity. Crushing, beating, and scraping operations in various combinations are employed in all types. The simplest machine is a pair of rubber squeeze rollers, which crush the stalk and free the ribbons from the wood.

Figure 2 shows a small fiber burnisher or brush equipped with a rotating drum with blades and a slot through which the stems are fed. With this simple machine a handful of stalks is fed into the slot and held in the machine until the woody core is broken and knocked out. The stalks are then pulled out and reversed for cleaning the other end. Some scraping action takes place, depending on speed of the rotating drum, shape of the blades, and length of time the stalks are held in the machine. If a stream of water is played on the fiber while it is in the machine, some washing is accomplished and some of the water-soluble cementing agents are washed away. The U.S. Department of Agriculture harvester-ribboner described later uses this rotating drum principle as the basis for its mechanical harvesting-processing field machine (*2*).

A great many machines for processing ramie have been designed and built over a period of about 100 years. For the most part they have aimed at decortication rather than ribboning. Since few are still in use it is apparent that they failed to meet some requirements of the ramie-processing industry. Mostly they lacked sufficient capacity to make them usable production machines. One or two are perhaps worth mentioning since either experimental models or shop production models are to be found around ramie producing areas.

The Short or Baproma (BAst-PROcessing-MAchine) is a belt-fed mobile ribboner that uses three sets of feed rollers, a double-angle breaker bar, and three intermeshing, bladed cylinders for beating and cleaning the ribbons (*3*).

FIGURE 2.—A small burnishing machine cleaning ramie fiber. This machine has a drum and ribboning action similar to the ribboner.

FIGURE 3.—A commercial adaptation of the ribboner for use in kenaf growing in Florida.

The Martí machine in Cuba, like the Baproma, is an end-fed machine. Both flip the ribbons over transverse bars or belts upon completion of the ribboning. Both are limited in capacity by the necessity of batch feeding (a handful of stalks at a time). With this method of feeding, it is rather difficult to use the machines at full capacity.

The machine shown in figure 3 is one of several that were built and operated by the American Kenaf Fiber Corp. These machines were copied, by permission, from the U.S. Department of Agriculture experimental ribboner and equipped with airplane-type wheels and an extended feed table. In use they were pulled around the field by a crawler-type tractor. Several men picked up bundles of kenaf, which had been cut with a modified war hemp binder. On the feed table the bundles were spread before being topped and ribboned. Two men removed the ribbons and placed them in field boxes, which were then dropped on the ground to be picked up for transport to a central processing plant.

Machines for Harvesting and Ribboning

Machines for harvesting and ribboning combine these two operations. The machines discussed above require some method of cutting and handling the stalks prior to ribboning. Hand cutting is commonly used where labor costs are low. Cutting with a mowing machine reduces labor requirements, but the cut stalks still need to be picked up and straightened for further processing. A limited number of war hemp binders (fig. 4) were available after World War II and although they were too lightly constructed for cutting ramie they could be modified for such use. They cut and tied the stalks into bundles, which was an advantage over other machines.

When the stalks are cut and ready for ribboning, they have to be carried to the machines, or the machines have to be sufficiently mobile to take to the field. There are advantages in both methods, but a machine that combines the harvesting and ribboning operations has considerable laborsaving advantages over other methods. An additional advantage can be gained with field harvesting and processing by leaving the bulk of the waste material in the field where it is returned to the soil without further effort.

Several agencies, private and governmental, have approached the problem with the idea of a combined machine. Currently in operation on either an experimental or a production basis are several machines, which are discussed here briefly as an introduction to a complete discussion of the U.S. Department of Agriculture harvester-ribboner.

The Dryer harvester-ribboner was developed over a period of several years in Cuba and Central America. Several experimental models have been built. They are developed around heavy tractors and are designed to handle the tall heavy Cuban kenaf. The machines consist of a tractor, gathering and cutting device, a Martí-like ribboner, and a pair of sweep chains for removing nonfibrous material from the ribbons (*3*).

The Cary harvester-ribboner was developed in Louisiana for harvesting and ribboning ramie. It utilizes a rotary cutter, a belt-and-chain gathering system, a crushing roller, and two pairs of sweep chains. Purchasers of several of these machines have modified them by replacing the sweep chains with rotary drums patterned after the U.S. Department of Agriculture ribboner drums. In addition, several self-propelled machines were

FIGURE 4.—A war hemp binder modified for use in ramie. The bundles of stalks are kicked out to the right.

built in Florida by Mr. Thomas Preston for Mr. Alex Ramey. These machines were of lightweight construction and used a short cutter-bar mower, twin drums patterned after the U.S. Department of Agriculture ribboner, and rubber belts for holding the fiber.

U.S. Department of Agriculture Harvester

Ramie harvesting must be a large central-station operation unless a smaller unit than the commercial raspador-type decorticator can be developed. Central-station operation is usually based on a minimum of 2,500 to 3,000 acres of land (*1*).

No satisfactory field harvesting unit for fiber plants is readily available on the farm machinery market. For this reason a relatively small combined harvesting-processing machine has a definite place in the domestic long vegetable fiber picture.

Such a machine could lower the basic operating unit to a few hundred acres rather than a few thousand acres and make fiber production possible for a small operation. Additional harvester-processing units could be added as the need for expansion arose.

To be practical such a machine should be low in initial cost, light in weight and easy to maintain, and should have a high capacity in relation to manpower requirements.

A harvester-decorticator might be built to meet these requirements, except that decortication needs close clearances between rotors and bedplates which in turn require heavier construction and greater power than ribboning.

A harvester-ribboner, on the other hand, has no critical clearances requiring heavy construction. Power requirements are nominal for ribboning although power and capacity are closely related, as they are in decortication.

FIGURE 5.—Early development of the twin-drum ribboner for stationary operation.

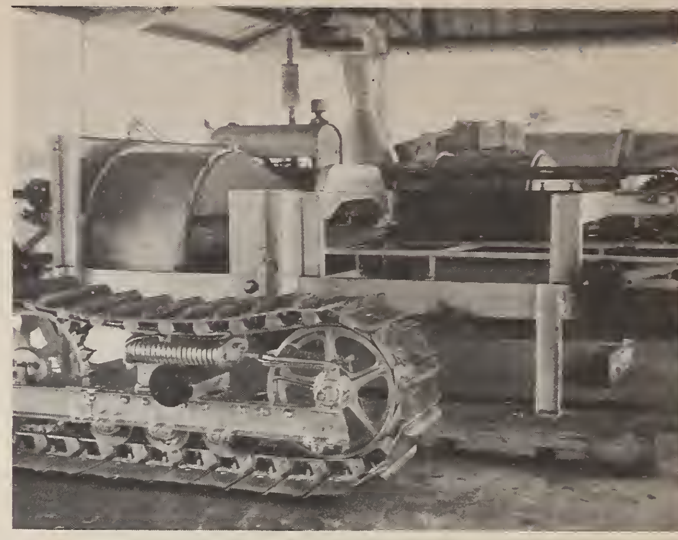

FIGURE 6.—Converting the stationary ribboner to a mobile unit by attaching tracks for use in soft ground conditions.

The U.S. Department of Agriculture harvester-ribboner was planned with these basic requirements in mind. Its development has been progressive, beginning with a stationary handfed single-drum burnisher (fig. 2). This machine consists of a covered rotating drum equipped with eight scalloped bars (*2*). The material to be burnished is fed into a narrow slot across the face of the cover and held in the machine briefly before being withdrawn and turned to burnish the other end. The burnisher did an excellent job of ribboning and formed the basis of the next development—the twin-drum mechanically fed stationary machine. Figure 5 shows the basic machine under construction.

This early ribboner had a rectangular framework of 6-inch channel iron with crossmembers placed to take the main bearings of the two rotating drums and the mountings of the lower grip chains. An upper frame spans the lower frame to carry the upper grip chains and to provide clearance for the stalks to pass. Power units, drum covers, and a feed table completed the first ribboner.

After laboratory testing, the stationary machine became the ribboning unit of the U.S. Department of Agriculture harvester-ribboner. A 4- by 6-inch box axle was installed at a point between the first and second drums. The axle was fitted to take either rubber-tired wheels or crawler tracks from an International Harvester Co. tractor. Figure 6 shows the crawler tracks on the ribboner. The feed table end of the ribboning unit was fitted with a ball hitch for attachment to a tractor drawbar. In this form the machine could be pulled around a field for use as a mobile ribboner.

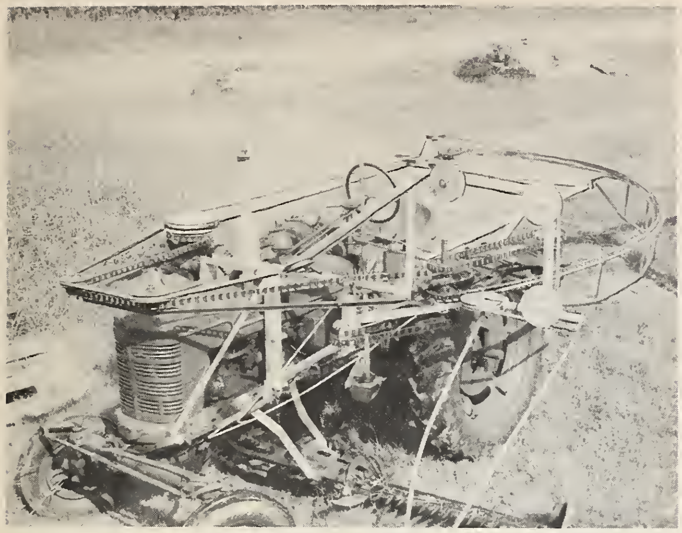

FIGURE 7.—A harvester mounted on the tractor. The left-handed cutter-bar mower can be seen in the foreground. The trussed track on the right carries the stalks to the rear to be deposited on the ribboner, which is towed by the tractor.

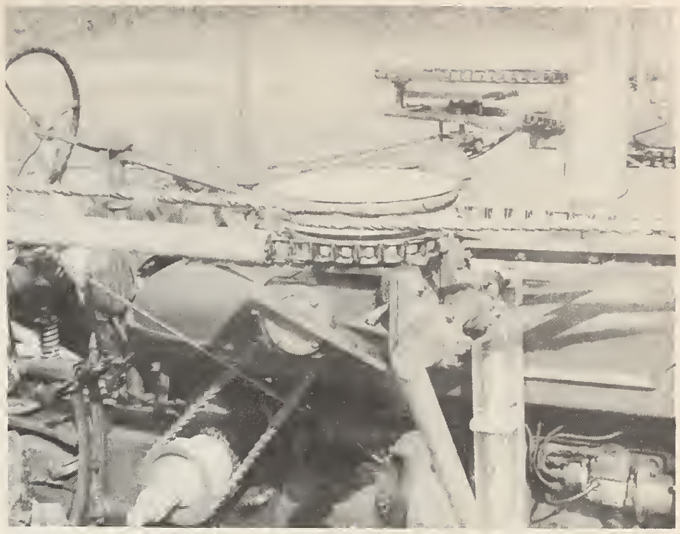

FIGURE 8.—The harvester mounted on the tractor used a combined rope and hook chain drive pulley and sprocket. A slip-clutch pulley on the belt drive of the tractor was used for power.

A Tractor-Mounted Harvester

A cutting attachment, together with an overhead conveyor mounted on a tractor, was designed to deliver cut and topped stalks to the feed table of the ribboning unit. Figure 7 shows the harvester mounted on a tractor. The power from the tractor was used to cut and convey the stalks and pull the self-powered ribboning machine.

Cutting was accomplished by use of a left-handed cutter bar attached to a mounting unit under the tractor. (The left-handed mower was required by the original construction of the ribboning unit designed for attachment to the left-handed war hemp harvester.) A standard tractor mower was modified for this purpose.

The conveyor gathered the stalks from a 4-foot swath just prior to cutting; conveyed the cut stalks to the rear, through a topping saw; and laid them across the feed table of the ribboning unit, which followed directly behind the tractor. The conveyor system consisted of a spring-loaded moving rope acting against a chain moving in a curved track. The track was so designed that the single-plane curve carried the stalks from the gathering point to the rear and to the far side of the tractor where they were released. The curvature was such that the spring-loaded rope acted against the periphery of the track to give sufficient pressure between rope and chain to hold the stalks.

The harvester unit was driven by several methods during the time it was in use. The cutter-bar mower was driven by a jackshaft extension from the power takeoff. The rope and chain mechanism was powered by a chain and angle drive through a sprocket on the rear tractor wheel. It was thought that a drive powered by the wheel would give a chain and rope movement exactly matching groundspeed.

The drive proved troublesome because of its long chain and other factors, which included inability to move the rope and chain without moving the tractor.

The drive was then moved forward, equipped with a gear reduction drive, and driven by a V-belt through a slip clutch attached to the belt pulley drive on the tractor. This drive was carefully worked out so that at full throttle the rope and chain would move at a speed slightly faster than tractor groundspeed in low gear. Figure 8 shows the drive in this position.

Several other modifications were made. These were, for the most part, attempts to improve and add flexibility to the height at which the stalks were to be gathered and topped. This is particularly necessary when going from one field to another with marked differences, in some years, between first, second, and third cuttings. All such adjustments on the tractor-mounted unit were field adjustments requiring considerable effort and were therefore made only to operate to best advantage in each field to be harvested.

A Ribboner-Mounted Harvester

The ribboner-mounted harvester was developed after a workable harvesting unit—operating independent from but in conjunction with a ribboning unit—had been tested. The next step was to combine the two parts into a unified mobile machine. The combined machine was tractor drawn and partially powered from the tractor's power

Figure 9.—A harvester mounted on the ribboner. Note the high arch to carry the rope back to the outside of the harvesting path.

takeoff. One or two gasoline engines mounted on the ribboner supplied the remainder of the power. An early version of the combined machine is shown in figure 9.

It is this form of the harvester-ribboner that is the subject of the detailed discussion which follows. When the various parts have been tried separately and in combinations and sufficient design data are available, a self-propelled harvester-ribboner can be built utilizing the principles determined from research. Such a machine will be more maneuverable than the present model and will give greater visibility and control to the operator.

The discussion is based on a normal progression of operations from harvesting to the final handling of the ribboned material. Certain operations may be carried out in an order other than that used here, but are discussed in their most logical order.

This order is dictated by the need to perform certain operations. The stalks as they stand in the field must be divided into a workable unit such as a swath, and gathered together so as to keep them under control while they are cut off at the ground and the tops removed. This followed by transport to ribboning position would constitute the harvesting phase. Ribboning then would consist of the operations that are performed to convert the stalks into the final product of the machine.

A Reel-Type Harvester

The basic principle of the grain binder, as used in rice binders and the war hemp binder, was adapted for use with ramie. Figure 5 shows a war hemp binder modified for use in ramie.

A heavy-duty cutter-bar mower for cutting the stalks just above ground level, a large reel for laying the stalks on a moving platform, and an elevator to raise the stalks to the feed table could be constructed as an attachment for the ribboner. The platform and elevator of this type binder are usually canvas. However, for heavy fiber stalks, these parts might better be constructed with chains to move the material.

The advantages of this harvester are the wide cut that is possible and its ability to harvest stalks of various heights. The disadvantage is that all the field trash, dead stalks, and grass will be picked up and transported to the ribboner. In normally clean fields of good fiber-quality stalks, this would not be a serious problem.

U.S. DEPARTMENT OF AGRICULTURE HARVESTER-RIBBONER

Harvesting

Dividing

The standing stalks in the field must be divided into those to be cut by the harvesting machine and those to be left standing for the next pass of the machine. This is more difficult to do than would appear from a casual look at an average field of ramie. A closer study usually reveals tops intertwined, stalks bent and leaning, and often considerable tangling from wind and rain. These are the conditions most likely to affect dividing, although wind from an unfavorable direction during harvest imposes a difficult condition. Figure 10

Figure 10.—A field of ramie badly damaged by wind and rain. The stalks around the measuring rod show the height of the normal field.

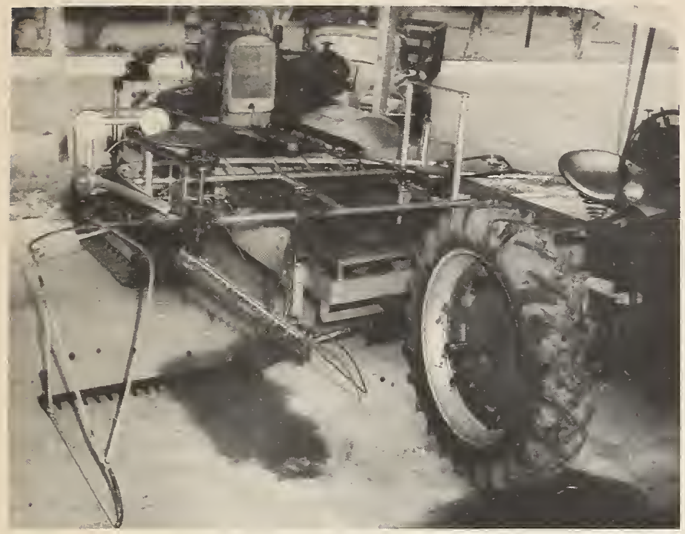

FIGURE 11.—The harvester mounted on the ribboner pivoted in bearings on the two upright posts could be raised and lowered in operation by a hydraulic cylinder at the edge of the feed table. The entire unit could be raised to several positions on the uprights to suit field conditions.

is an example of severe damage that can be expected occasionally. This field in the Florida Everglades would normally be considered impossible to harvest; however, a fairly satisfactory job was done by the U.S. Department of Agriculture harvester-ribboner in June 1959.

Several problems are involved in dividing stalks for harvesting. One of the most difficult is dividing and cutting the same stalks. All early models of the harvester, including the tractor-mounted one, used a cutter-bar mower, and part or all of the divider was attached to the outer shoe and, for stability, to the main frame of the ribboner (figs. 11 and 12).

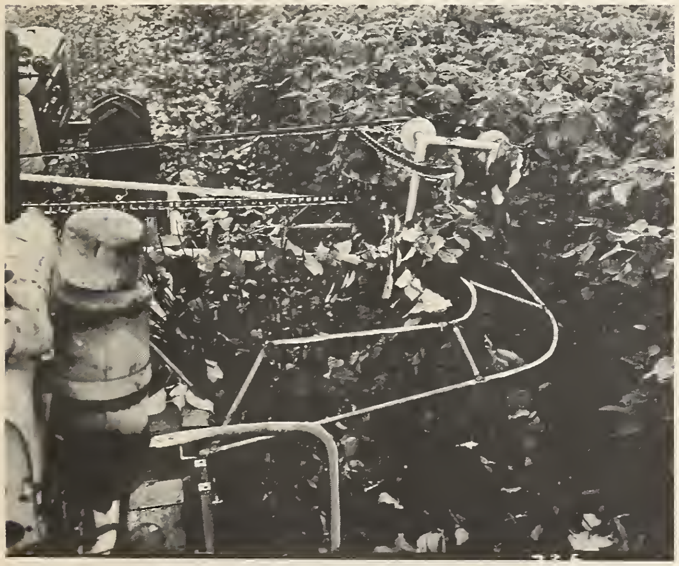

FIGURE 12.—The pipe framework which connects the outer shoe of the cutter bar to the frame of the ribboner serves the double purpose of dividing the swath and holding the cutter bar in position.

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The substitution of a rotary knife for the cutter-bar mower brought new problems to the task of dividing the stalks. There was no part of the rotary system to which a divider could be attached without creating a more serious trash collecting problem. For this reason the dividing parts were attached to the overhead harvester frame and had rods that extended downward and into the stalks ahead of the cutter. This point must be as near the ground as possible, since it represents the cutting point as well as the dividing point.

The early model of the ribboner-mounted harvester, as shown in figures 9, 11, and 13, was pivoted in a holding frame. Gathering height was adjusted by tilting the frame with a hydraulic cylinder. Any divider parts attached to this tilting frame moved in an arc as the frame was raised and lowered, which moved the dividing point several inches to the right or left. This was no serious problem when part of the dividing was done by the frame attached to the outer shoe of the cutter bar. However, with a rotary cutter, and no rigid divider at ground level, an adjustment for cutting height meant a change in dividing position. In fields having little variation in height this could be compensated for by an initial adjustment. In later modifications of the harvester unit the tilting frame was removed, which made possible many improvements in dividing.

FIGURE 13.—The tilting-type stalk conveyor in an extremely angled position (in a field of kenaf). When raised for tall stalks the dropping point is lowered, which results in an unfavorable dropping pattern on the feed table.

A correct division of the stalks to be cut and those to be left standing is fairly simple when done near the ground. The divider must lift bent

FIGURE 14.—The divider on the harvester moving through ramie. The part on the left divides the stalks to be cut. Fingers on the chains on both sides move the stalks to the gathering chains.

stalks, separate tangled ones, and direct them toward the gathering point. Rods attached to the divider and shaped like a three-sided wedge push the divided stalks toward the center of the cut for gathering, for lifting them free from the stalks not to be cut, and for deflecting the uncut stalks away from conveying ropes and chains. Figure 14 illustrates this type of divider.

Gathering

In this publication, gathering refers to the overhead-type harvesting unit which has, in one form or another, been used on all harvester-ribboner equipment developed on this project. Gathering is a continuation of dividing and is completed just before the stalks are cut by the cutter-bar mower or rotary cutter. A 1-inch rope—later a ¾-inch pitch roller-chain—held against a No. 55 agricultural hook chain holds the stalks from a swath up to 4 feet wide and compresses them between the holding or conveying chain and rope. Only the tops of the stalks are moved directly by gathering since the roots are still uncut at the ground until they are completely held in the conveying chains. Therefore, most of the movement is sidewise with only enough rearward movement to overcome the forward travel of the machine.

The importance of mechanical aids in the gathering unit was recognized at an early stage of development. Agricultural chains with various types and shapes of fingers brazed to the side pieces were used. Pieces 2 to 3 inches long and set to slope back from, rather than to hook into, the stalks were found to be satisfactory, and because of the backward slope did not hang up in the stalks when returning around the sprockets.

All mechanical fingers were installed on the chain side of the gathering unit until the rope was replaced by a chain. This was necessary because of the problem of getting sufficient power on the rope side to drive the gathering chains.

Some mechanical help was supplied to the rope side by adding curved metal rod fingers on the rope pulley. They helped move the stalks into the constriction of the chain and rope at a point where considerable difficulty had been experienced. Again the fingers were curved in a direction that permitted them to pull free of the stalks.

The change from rope to roller chain was part of an extensive overhaul of the harvester unit in 1959. The use of chain, and other changes, made possible a mechanized gatherer employing agricultural chain with 4½-inch fingers. It was completely shielded except for the fingers, which were left exposed over their working area and covered on the return (fig. 15).

Cutting

Cutting the standing stalks must be done efficiently in any harvesting system. With overhead gathering it is very important that all stalks be cut. Uncut stalks that are gripped by the holding chains will be pulled from the ground at a considerable strain or else must be stripped and pulled out of the holding chains.

All early models of the harvester employed a reciprocating cutter-bar mower of commercial design and manufacture. Any trail-behind or tractor-mounted mower can be adapted for this purpose by use of a suitable mounting and drive system. Serrated ledger plates and plain knives

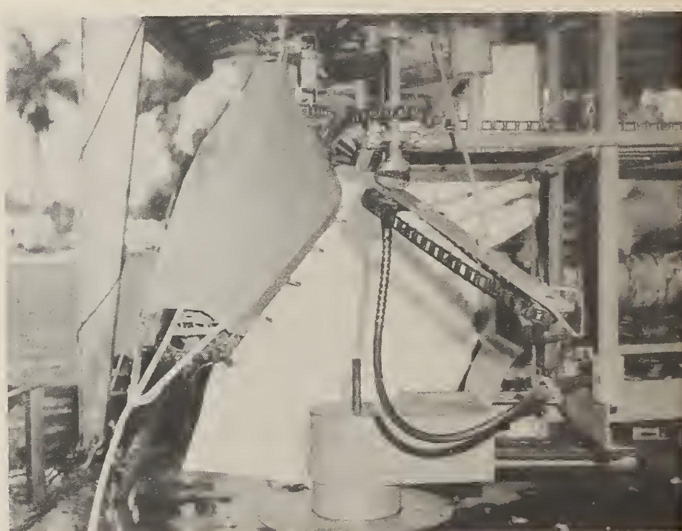

FIGURE 15.—On the left is the stalk divider with fingered chain to move the stalks up and into the conveyor chains. The sheet-metal cover serves as a guard and also lifts and separates the stalks to be gathered from those to be left for the next cut.

have given satisfactory cutting in all fiber work on this project.

Mounted as an attachment to the ribboner, the mower must be offset by several feet because of the width of the ribboner. A 2:1 V-belt reduction drive is installed in the offset between the jackshaft and the housing of the mower. A somewhat slower speed gives superior cutting in heavy and woody fiber stalks. The jackshaft is also utilized to drive several other parts of the harvester.

Maximum power from the tractor is used by running at full throttle and adjusting groundspeed through gear shifting. In practice this means selecting the most practical forward gear speed at full throttle and then gearing all drives taken from the tractor to this speed.

The inner and outer shoes of the standard mower need not be changed except to replace the inner shoe rod with a divider rod, which is longer and extends forward, and to remove the grass board, which has no value in this application.

Part of the mower mounting on the ribboner is a rigid brace from the frame to the inner shoe to replace the usual breakaway device. The brace should be located on the hinge point of the coupling bar to permit the shoe to ride the ground. The entire cutter bar is allowed to ride heavily on the ground to overcome a tendency to ride up on the stubble and to cut as close to the ground as possible.

An alternate cutting mechanism can be supplied by using a rotary cutter. For this purpose, a shop-fabricated unit utilizing shafting, steelplate, standard bearing, and smooth section mower knives was constructed.

The ¼-inch circular plate is 30 inches in diameter. This appears to provide sufficient flywheel effect for average cutting. It could be made heavier or weighted if necessary. Six knife sections spaced around the circumference extend 2 inches beyond the edge, and give an effective cutting width of 34 inches. The plate is bolted to a hub welded to a 1½-inch round shaft. This unit is attached to a suitable frame with pillow-block bearings, is equipped with a two-groove V-belt sheave, and is belt driven from a hydraulic motor. Figure 16 shows the cutter with simple shields to protect the shaft and belts from trash and wrapping stalks.

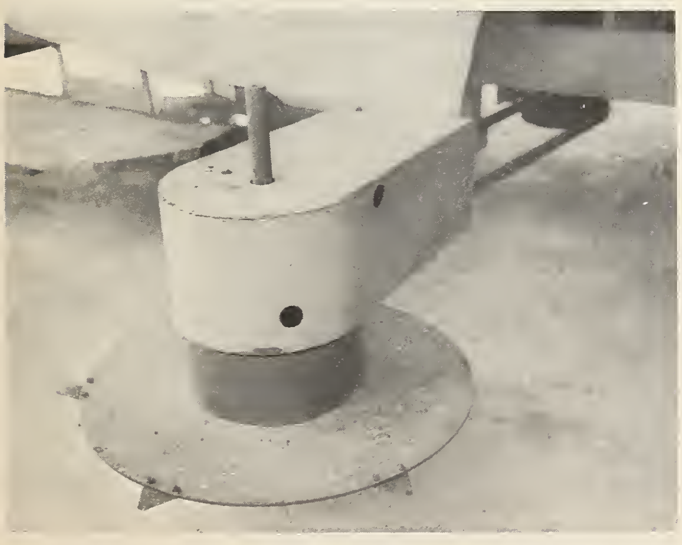

FIGURE 16.—The rotary cutter with three of its six knife sections in place.

The plate rotates clockwise. A rotation speed of 260 r.p.m. at no load is provided by the present hydraulic drive. This is sufficient to clean cut at present groundspeed.

A hydraulically driven rotary cutter of this type must be started before forward movement of the machine, at least when starts in the middle of a field are necessary. Otherwise stalling occurs in heavy stalks. The first rotary cutter was driven by a hydraulic motor with power derived from a hydraulic pump driven from the power takeoff jackshaft. This drive arrangement prevented prior starting because it lacked separate clutching for the power takeoff and for the tractor transmission. A constant running power source was devised for a later model of the harvester-ribboner.

The rotary cutter is field adjusted for cutting at a fixed height. This could be improved by mounting the hydraulic motor directly to the shaft and by using a hydraulic cylinder or mechanical leverage to adjust cutting height. A floating cutter maintained at a predetermined height above the ground by a sensing element and solenoids might be developed, but would serve no important end. The most urgent adjustment needed is one to raise the cutter when the ribboner sinks to a lower level in soft ground. Sometimes this is a field condition and an initial adjustment is all that is needed. At other times it is encountered only in parts of a field and then momentary adjustments are required. Without some flexibility in cutting height, the cutter must be set high enough to avoid trouble.

Topping

Removing excess plant height is necessary to limit total stalk length to be fed to the ribboner. In general very little is lost in either fiber or quality by removing the leafy, branched tops, which contain at best a small percentage of the total fiber. Ramie stalks rarely grow to a height that exceeds the capacity of the ribboner; however, the leafy crown interferes with handling and feeding into the ribboner and should be removed by topping.

After early attempts to use a 10-inch circular crosscut saw proved unsatisfactory, a 16-inch 32-tooth ripsaw was tried and satisfactory results were obtained. This blade is rotated in the opposite direction from that used in sawing and has

the back edges of the teeth sharpened to a knife edge.

The saw is held in a horizontal position by a mandrel mounted in bearings. Because the gathering and cutting height of the ribboner is variable, the saw mandrel is connected through a 7-foot flexible shaft to a jackshaft and then by V-belt to the extension of the power takeoff shaft. The jackshaft is hinged in its mountings and connected to the tractor clutch by cable. This permits the saw to override when the power takeoff is stopped abruptly. The saw should be operated at a fairly high speed. A 16-inch blade at 2,000 r.p.m. gives good clean cutting of the tops. To provide this speed the V-belt drive has a 4:1 ratio between the power takeoff and the saw.

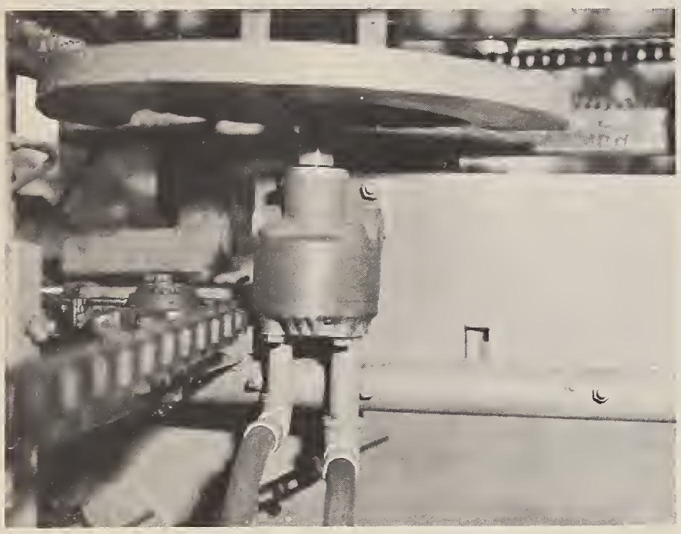

FIGURE 17.—The topping saw attached to the shaft of a hydraulic motor. The motor and shield are attached to the frame of the harvester.

A hydraulic drive may be used for the topping saw. A gear-type hydraulic motor is used, and the saw is mounted directly to the motor shaft by use of a suitable mandrel. Figure 17 shows the mounting of the motor, the saw, and its shield. The topping height is varied by using looped sections of hydraulic hose between the motor and the frame of the ribboner. The saw motor is driven with a vane-type pump through a hydraulic valve.

The location of the topping saw depends on the disposition to be made of the topped portions of the plants. Also, topping should be done ahead of the first of the brackets that support the outside portion of the carrying chains. The brackets should cross at approximately the height of the saw, thus allowing the severed tops to pass over and stalks to pass under the support.

Figure 18 shows the tops being conveyed by their holding chains and moving to the rear to be dropped to the cutover part of the field. If extremely long tops must be moved, two sets of chains should be used to carry the tops. One of these should be just above the topping saw, and the second set a foot or more above the first.

FIGURE 18.—The chains in the upper right carry the tops to be dropped behind the rotary cutter below. The stalk-carrying chains turn 90° to move the stalks to the left to a dropping position on the feed table.

It has been found advantageous to have a device of some sort to hold the stalks against the saw. The most satisfactory arrangement has been a 1/8-inch plate, cut with a curved edge, and mounted opposite beneath the saw (fig. 19).

Overhead Conveying

"Overhead conveying," a term used in the sense of moving fiber stalks by gripping them in their upper portion, is a fairly adequate description of

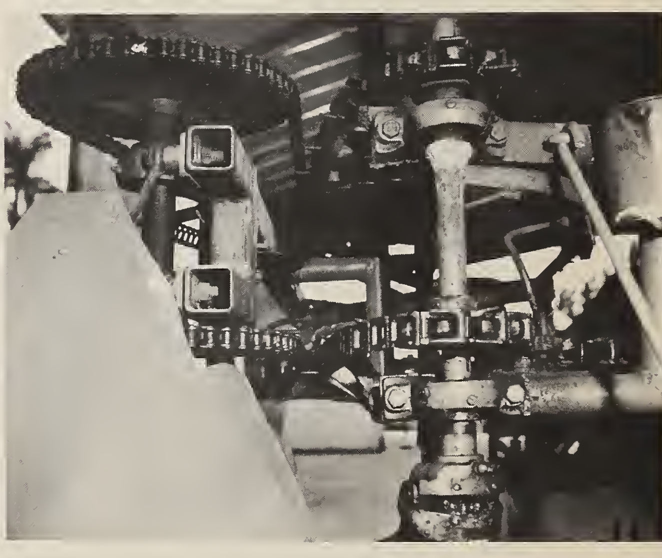

FIGURE 19.—The harvester gathering chains come together at this point. Those above carry the excess top material, and those below carry the stalks to the ribboner. Between them is the topping saw.

the system used on the U.S. Department of Agriculture harvester-ribboner. As mentioned previously, the fiber stalks standing in the field are divided into a swath to be cut and their tops gathered together. At this point they are cut near the ground and must be held firmly in the conveying system until released in the proper position for ribboning.

Topping is best done at this point as the fiber portion of the stalks move in one direction to the feed table, and the tops in another to a discharge point.

The topped stalks are held in a vertical position for conveying to the feed table. The feed table is horizontal and approximately 3 feet above the ground. The stalks, therefore, must be laid or dropped in a horizontal position and as nearly as possible at a right angle to the grip chains of the ribboner.

The U.S. Department of Agriculture harvester-ribboner carries the stalks around a 90° bend to utilize the holding power of a peripheral curve. In theory, by using other means of pressing the stalk-carrying chains together and by turning the ribboner 90°, a straight track could be used. Any advantage to be gained might be offset by a greater overall width of the machine.

A combination of No. 55 agricultural hook chain and a 1-inch rope was used on the early models of the harvester. The hook chain was modified by building up the side bars with pieces of flat stock and at intervals with small triangular pieces brazed to the lower side bars, which keep the stalks moving with the chain and also support the rope when it is forced away from the chain by large stalks. This tendency of the rope to fall away from the chain required several modifications, the first being the addition of the pieces to the side bars. The parts built up on the side bars form a trough in which the rope lays. Figure 20 shows various types of modified chain, one with rope and two with the roller chain that replaced the rope in later modifications.

The agricultural chain moves in a track, a cross section of which is also shown in figure 20. It is

FIGURE 20.—Three sections of tracks and chain and rope combinations used on the harvester for conveying stalks to the ribboner.

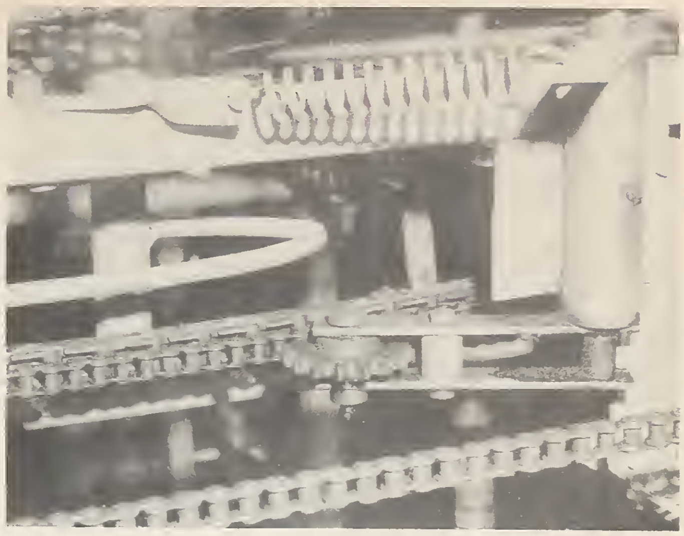

FIGURE 21.—The stalk-crushing sprocket on the harvester conveying chains. The spring applies the pressure necessary to crush the stalks between the two chains to improve their holding power.

made of 1½- by ¼-inch flat bar with two 5⁄16-inch rods welded at the edges to fit the back side of the chain.

The track is made up of two slightly curved sections on each side of a large sheave, which has a surface of the same cross section as the track. This is located at the sharp 90° turn and rotates with the chain to reduce the sliding friction of the chain against the track at the point of severe friction. This sheave was added to make it possible to reduce the long curved track to two short curved sections with the sheave between. Figure 7 shows the type of long curve used in the early stages of development.

A small wheel with a groove to fit the rope is used to crush the stalks between the rope and chain to imbed the stalks in the chain. If this is done as soon as the stalks enter the conveyor, they are prevented from slipping and dropping to the ground. A further preventive is provided by adding a pipe an inch or so over the chain and protruding over the rope slightly at first and several inches at the point where the stalks are to be discharged. This in effect bends the 8 inches of stalk between the conveying chains and the topping saw, over the rope at a sharp angle. The sheave at the sharp turn of the track has a wide flange on its top face to keep the stalks bent. A curved pipe below the wheel was a necessary precaution for keeping the rope from slipping at this critical point.

Figure 21 shows the press wheel idea modified for roller chain. It uses a spring-activated arm instead of the sliding arm of the rope press wheel and a roller chain sprocket for the wheel. Above is the pipe for bending the stalks and at the extreme left the turning section of the track with its top flange and pipes above and below.

The use of rope for one side of the stalk conveyor made necessary a high arch at the entrance and a wide extension at the discharge point. The arch returns the rope over the stalks to the outside of the track, and the extension permits the stalks to drop to the table (fig. 13).

Stretching was a continuing problem with rope. Prestretching before and after splicing was not very helpful. Several feet of takeup had to be provided to break in a new rope. Information as to the possible life of good-quality rope is not available. However, experimental work indicates that rope life would be short and replacement time consuming under continuous field operation, since a long splice is required followed by a break-in and adjustment period.

Roller chain replaced the rope in a complete rebuilding of the harvester. The rope moved in two planes in order to return over the stalks to the outside. Since this was not possible with the roller chain, it was designed to run in a frame all on the outside of the stalks. Three points of attachment are used: (1) just behind and at the same height as the topping saw, (2) at the outside turn of the returning chain, and (3) at the drive point where the stalks are dropped onto the ribboner. The second is a spring idler wheel, which adds the pressure needed to hold the stalks between the two chains. Figure 22 shows the idler. The square tubing houses a heavy spring.

The drive sprocket shown in figure 23 is driven by a separate chain from the gear reducer, which drives the agricultural hook chain. Also shown is the adjustable idler that forms the separation of the chains at the drop point.

The chain used to replace the rope is a 3/4-inch pitch roller chain which runs in the groove made by the side bars attached to the No. 55 hook chain.

FIGURE 22.—A tightener on the return side of the conveying roller chain on the harvester. The telescoping square boxes contain a heavy spring.

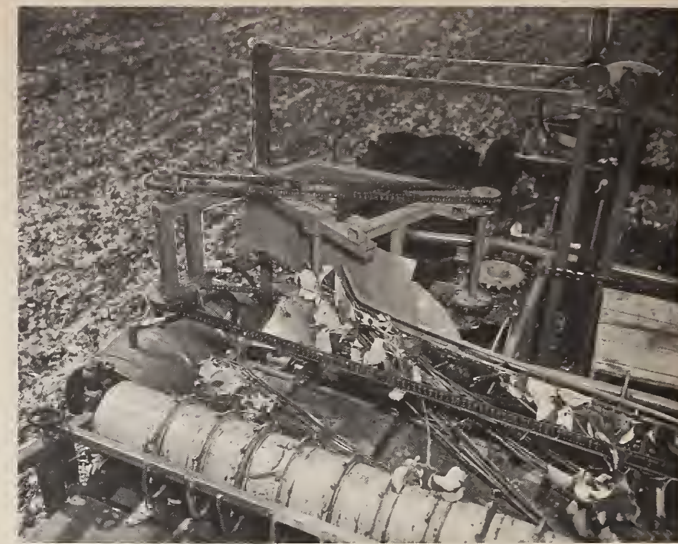

FIGURE 23.—The roller chain driving the outside gathering chain on the harvester has a high clearance to permit the stalks to drop. Beneath the center of the chain is the dropping point adjustment.

Figure 20 shows this combination and also the long fingers added to replace the triangular section. These are offset to allow adequate space for the roller chain.

Dropping

The cut and topped stalks are dropped onto the feed table of the ribboner. This is the principal purpose of the overhead conveying track. The feed table is horizontal, several feet above the ground, and has chains that move toward the rear of the machine parallel to the line of travel. The portion of the field being cut is at one side of the ribboner; hence the stalks must be moved in several directions in a relatively short time and small area. The overhead conveying track turns 90° and pulls the tops of the stalks across the feed table and at the same time pulls the butt ends from the ground to a position on top of the feed table. From this position the stalks are dropped from the conveyor and are free to be moved by the feed table conveying chains into the ribboner or, if they are to be crushed, into the crushing rollers.

Figure 23 shows how the stalks are pulled across and dropped on the feed table. The exact point at which the stalks are to be released depends on several factors. Length of the stalk, height of the holding point, both above the ground and above the feed table, and the position the stalks should be in relation to the ribboning drums. The length of stalk cut should be the greatest length the machine can ribbon, but consistent with gathering the stalks at a height which will harvest as much as possible from a field.

In the first stages of developing a harvester to be mounted on the ribboner, the gathering height was adjusted by tilting the frame on a central

mounting post. Figure 13 shows this arrangement. The pivot point is on the axis of the gear-reduction drive shaft. As the illustration shows, the drop point is lowered as the gathering point is raised for tall stalks. In effect this is the reverse of what should happen. Taller stalks are dropped before they are pulled far enough onto the table, and shorter stalks are pulled too far.

Figure 24 shows a modification designed to keep the harvester level. The frame with all the dividing, gathering, and conveying parts is raised and lowered with a double-acting hydraulic cylinder and three steel cables. The cylinder has a 16-inch stroke, and by adding a 12-inch extension, two ranges can be used for a total of 28 inches, from

FIGURE 24.—The harvester unit as mounted in a level position. It is raised and lowered by the hydraulic cylinder and cables. The articulated chain drive in the foreground can supply power through the entire 28-inch vertical adjustment.

53 to 81 inches. A cylinder having a longer stroke could be used to achieve any practical range.

Power for the adjustable harvester is supplied through an articulated driving arm, shown in figure 25. Through this drive, power from the tractor's power takeoff, driving an extension shaft, is transmitted to a horizontal angled gear-reduction drive which in turn drives both chains. As mentioned before, the speed at which the gathering chains move is held at approximately groundspeed.

The horizontal position of the harvester, as opposed to the tilting, changes the dropping pattern of the stalks. The shorter stalks are pulled farther onto the table and dropped from a lesser angle. The longer stalks, dropped from a greater angle, will have their butt ends nearer the edge of the feed table. This results in a satisfactory relationship to the ribboning drums and to the grip chains that move them through the ribboner.

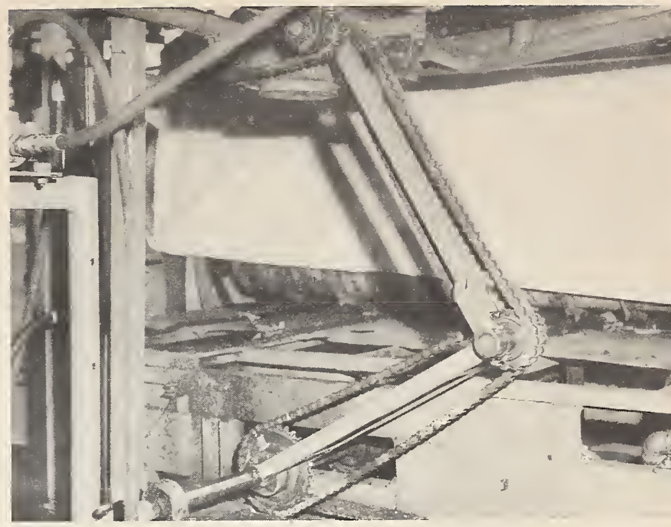

FIGURE 25.—The articulated arm chain drive between the jackshaft from the power takeoff and the angle gear drive on the harvester. This permits raising and lowering the harvester while in operation in the field. The upper and lower joints pivot on bearings on jackshafts.

Ribboning

As mentioned earlier, the ribboner is the basic part of the U.S. Department of Agriculture harvester-ribboner. It may be used independently either as a stationary machine or as a mobile field ribboner. However, the most likely application will be as part of a field harvesting and processing machine. In this form it removes the problem of hauling a large volume of green material to a processing point and then hauling away the waste material that results from removing the fiber (3 to 5 percent of green stalk weight) or ribbons (30 to 40 percent of green stalk weight) from the green material.

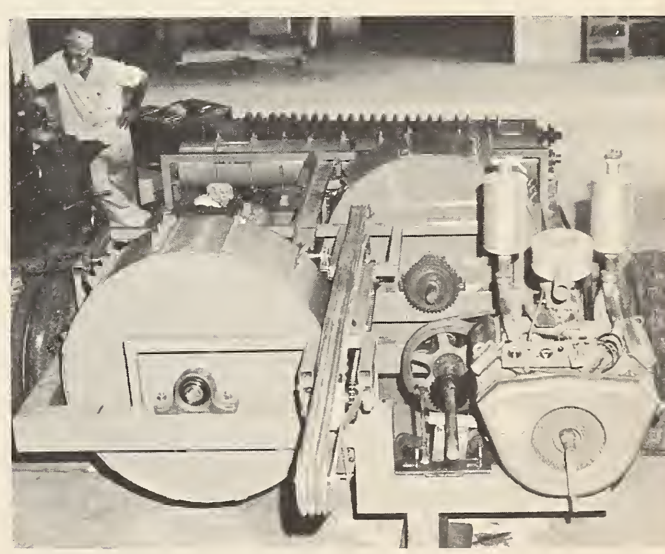

FIGURE 26.—The offset grip belts shown in relation to the ribboning drums.

Essentially the ribboner consists of two rotating drums, and a set of chains or belts for holding and moving the stalks. Figure 26 shows how the belts are offset in relation to the two drums. A crushing system, if needed, and a feed table, power units, and mounting wheels make up the mobile unit presently in use. Figure 27 shows a complete harvester-ribboner in field operation. The tractor supplies power for towing and for operating one two-way hydraulic cylinder. In final form the tractor would be displaced in favor of a self-propelled machine. The hydraulic cylinder can be driven from power available on the ribboner.

FIGURE 27.—The harvester-ribboner in operation. Note the pole for holding ribbons.

Drums

Knowledge of the design and use of the drums is necessary to an understanding of other functions such as feed table, crushing rollers, and grip chains.

The twin drums, one referred to as the butts drum and the other as the tips drum, are the working units of the ribboner. All other equipment either prepares the stalks for the drums or moves them to and from the drums.

The stalks are fed up over the top of the drums, and under a cover. In the burnisher shown in figure 2, one end of the fiber stalks is more or less pushed through a slot against the rotating drum. The knives, or scalloped blades, break up and comb out the woody core and other material as the stalks are worked between the drum and the cover. After a sufficient interval in the machine, the stalks are withdrawn and reversed to repeat the operation on the other end.

The capacity of this machine is limited to what an operator can hold by hand. Because this type of machine did such a good job of ribboning on a

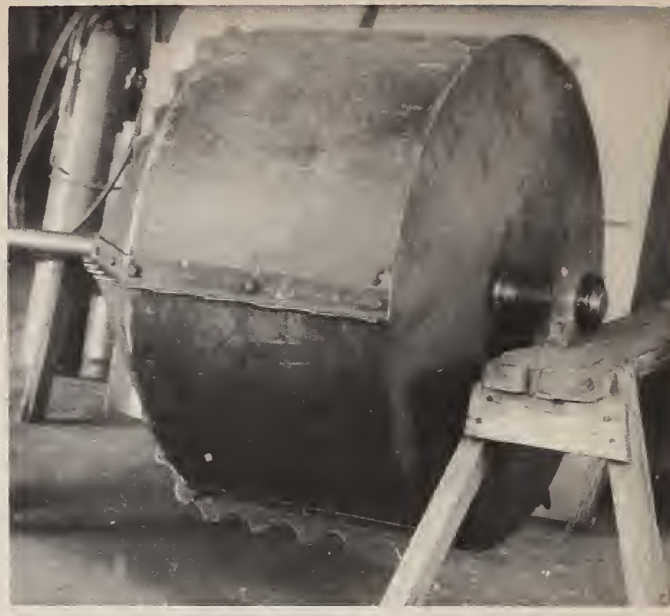

FIGURE 28.—A drum being assembled for the ribboner. Note the shape of the blades.

variety of bast fibers, it was decided to adapt the principle to a larger capacity machine that would eliminate as much hand operation as possible or at least decrease greatly the man-hours required to produce a pound of fiber.

Feeding the ends of stalks into a machine in batches did not seem practical for volume production, and for this reason the drums of the ribboner were fitted with cone ends so that the fiber stalks could be fed in at the end and moved across the drums in a continuous flow doing one end in the first drum and then the other end in a second drum.

Figure 28 shows a drum under construction and figure 29 shows two drums and their relation to

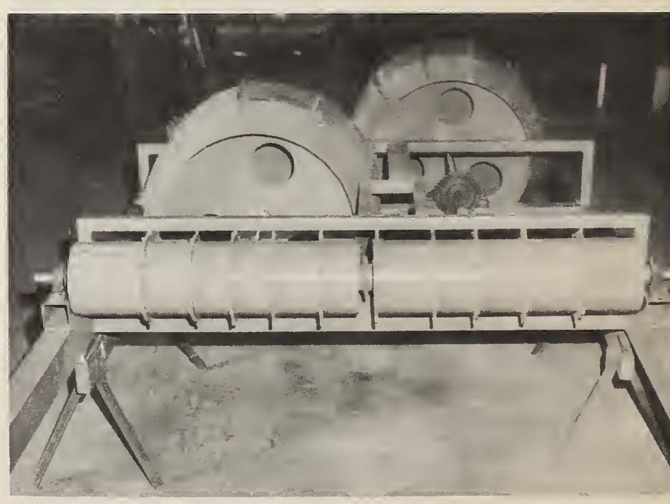

FIGURE 29.—The two 42-inch drums on the ribboner are overlapped to provide cleaning for the middle of the stalks. The drum on the left will ribbon the butt ends and has 10 blades. The drum on the right will ribbon the tip ends and has 12 blades.

each other. The nearer drum rotates counterclockwise and the farther, clockwise. In operation the stalks are gripped near their middles and moved toward the cone ends of the drums. They are held at a right angle to the drum axis so that as the gripped portion moves past the first drum, one end of the stalks is carried over the cone and into the drum where they are held down by the covers. As they move across the drum, the knives or blades ribbon them and the ribboned ends are then discharged onto a second set of grip chains, which are offset for this purpose. The unribboned end of the stalks now passes through the second drum. This in very general terms is the operation of the ribboner.

The drums are rolled from 1/8- or 3/16-inch black sheet iron with a welded seam. End plates cut from 1/4-inch plate have been found satisfactory, and may be welded or bolted to the drums. Care must be taken to have the end plates fit tightly and to have their hubs concentric to the drum. The hubs may be turned from 4-inch round shafting and welded to the end plates. They require keying to the shaft, although welding would be satisfactory if distortion can be avoided. The recommended minimum size for the shaft is 2 inches.

The cone shape on the drum can be rolled separately and welded to the drum or can be an extension of the roller cylinder. After end plates and hubs are in place, this extended portion is notched with a series of deep V's calculated to remove sufficient material so that when the edges of the notches are brought together, a cone shape results. A simple jig consisting of a bearing on the shaft and an arm with a curved plate with the desired radius can be made and used as a guide when hammering the notched sections into place and as a clamping block for welding.

The size of the drums depends on the total length of stalk to be processed and on the point on the circumference at which the stalk will be held. A diameter of 36 inches is a suggested minimum; however, if space permits, a 42-inch drum is preferable. Each drum ribbons one end of the stalk, and the middle of the stalk is worked to some extent by both drums. This portion is the most difficult to work since the holding chains require clearance as they pass the drum.

The length of the drum, exclusive of the cone section, is about 16 inches. On experimental models this allows sufficient space to try various scraper blades and has been found adequate. A length of 12 inches would be a minimum. Most of the ribboning action occurs in the first 6 inches, but additional cleaning and separation of the fiber strands can be accomplished by the additional length.

Each drum is equipped with a set of knives or blades (fig. 29). The number depends somewhat on the diameter and to a greater extent on the amount of scraping action desired. A 36-inch drum should have at least 6 blades and larger drums 8 to 12. The first drum ribbons the butts, which require more of a beating action than scraping. The second drum ribbons the tips, which are smaller and more difficult to ribbon; this is best accomplished by scraping and combing.

The blades are designed to produce these three types of action: beating, scraping, and combing. The blades have a scalloped design (fig. 30). They are alternated around the drum to bring the peak of one following the low point of the blade ahead. This produces a beating action on the stalks, and as the wood is knocked out a scraping action results as the fiber strands lay against the blades. The scalloped shape produces the combing action as the alternating high and low points split the strands.

In theory, the phasing of the highs and lows could be arranged to repeat every third, fourth, or even the complete set on the drum but no practical value would likely result.

The scraper blades are rough cut from 1/4- by 2- by 2-inch angle iron with a cutting torch, then ground and filed to shape. Edges should be rounded and smooth.

Each blade has an extension down the face of the cone section. It has a scalloped pattern similar to the blade except that it tapers to a point and is hook shaped, to "walk" the stalks up the cone onto the drum. The blade is cut through the vertical web of the angle iron to permit bending the extension down to the cone section. The space left is filled in with pieces of scrap and welding to give a smooth contour at this point. The blade can also be cut in two sections and welded together.

A flat section of drum has been found useful at the discharge end. It smooths the ribbons and thus eliminates the bunching and jerking which results if the scalloped blade continues to the edge of the drum.

The blades can be fastened to the drums in several ways. One-half-inch nuts welded inside the drum during construction may be used with capscrews to hold the blades in place. Two bolts on the straight section and one on the cone section have been found sufficient. Handholes in the end plates will give access to the inside of the drum. This makes it possible to use bolts for holding the blades, and in addition permits changing the number of blades. This system has been found best for experimental purposes; however, welding would be a very satisfactory method for permanent construction. Some welding of the ends is always useful to close small gaps at the ends of the blades to remove points at which fiber may be caught.

The shape of the blades is the same for both drums. However, since the drums rotate in opposite directions, the blades should be laid out so

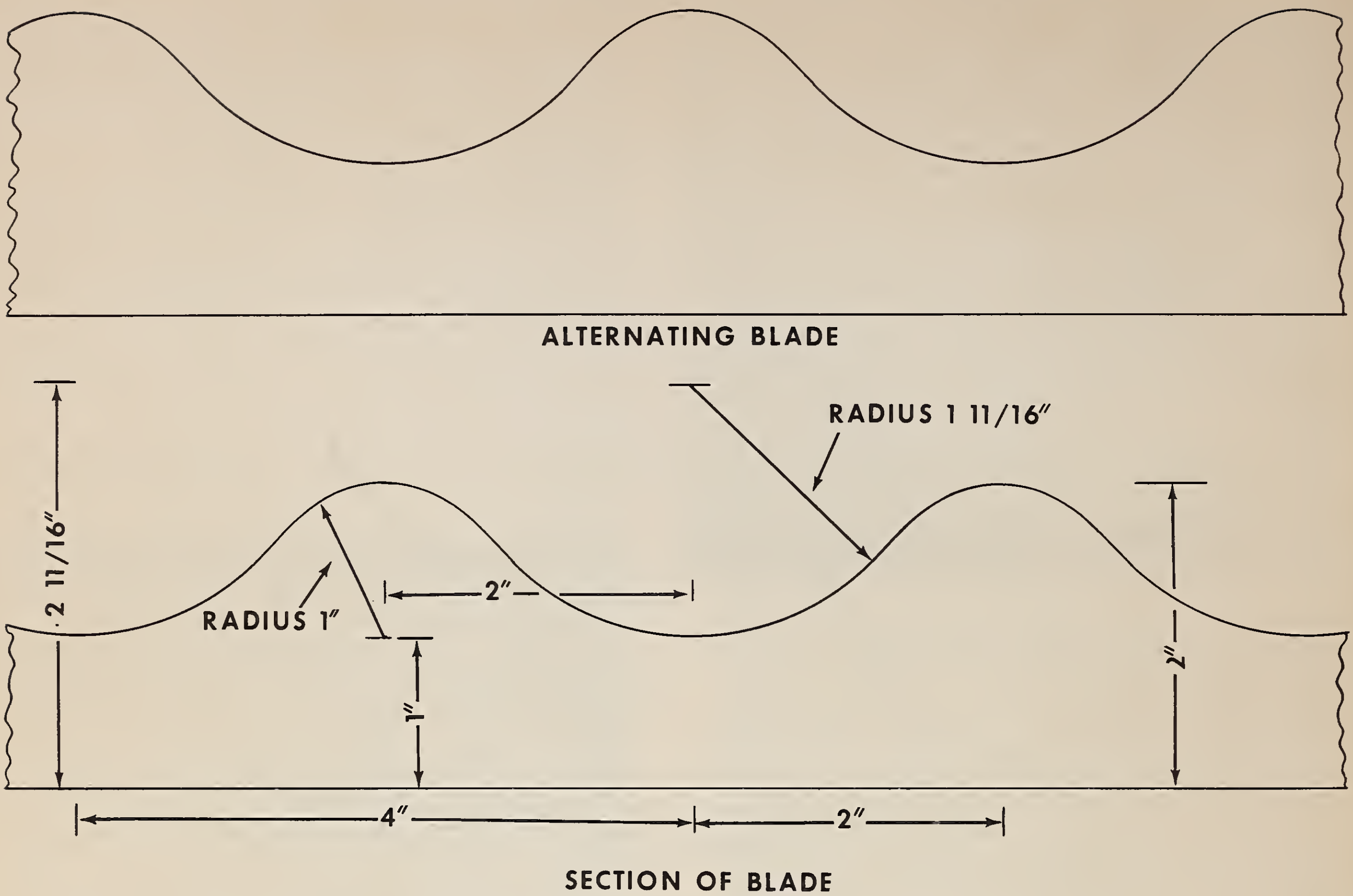

Figure 30.—Cross section of blades showing scalloped design.

that the vertical or scalloped leg of the angle iron leads in the direction of rotation.

The completely assembled drum should be reasonably well balanced. In addition, the points of the blades should be sanded or ground to avoid excess height. It is not necessary to even all blade points to a straight line, although building up a few lows and cutting down a few highs greatly improves ribboning.

The speed at which the drums are operated depends on their diameter, the material being ribboned, and the time required for the stalks to move across the face of the drums. Between 200 and 300 revolutions per minute for drums 36 to 42 inches in diameter has been found to be a good working range. Grip-chain speeds with a range between 75 and 90 feet per minute, together with the above drum speeds, should meet all conditions.

Each drum has a sheet-metal cover over approximately one-half its diameter. The covers are an inch or so wider than the length of the straight section of the drum and start at the grip chain and extend over the drum to a point below the frame. The sheet metal is held to shape with bent angle-iron pieces and brackets. Each cover has a shield over the cone section and one on the discharge end. The edge of the cover beside the grip chains has a pipe or rod extending just above the grip chains to give a smooth, gentle radius against which the stalks slide while they are being held close to the blades on the drum.

The covers have a clearance of from ⅛ to ½ inch measured from the high point of the blades.

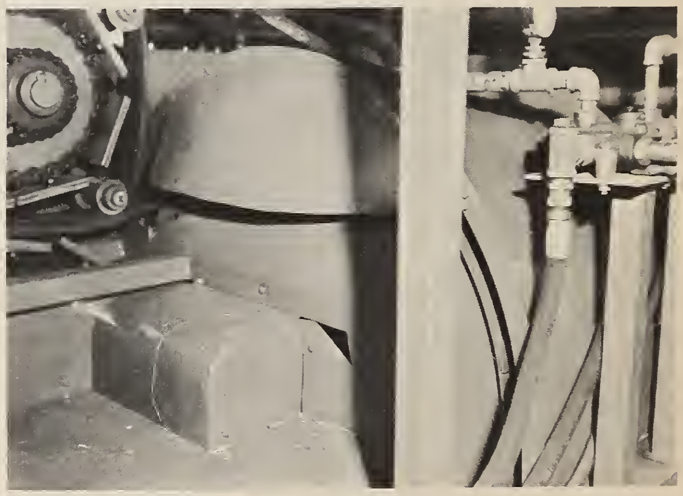

Figure 31.—The drum cover and the shields which direct the discharged ribbons into the grip belts to be held while the unribboned half of the stalks are processed in the second drum.

It is not critical, as the ribbons are pulled down against the drums by friction and gravity and tend to cling closely to the drum except at the point next to the grip chains where they must be held close by the rod mentioned above. The covers direct the waste material down to the ground and help to prevent the stalks from bouncing free of the drums, particularly as they enter and leave. Figure 31 shows how the shield at the discharge end is almost vertical and deflects the ribbons down onto the grip chains, or belts.

Feed Table

The feed table is the transfer point between the harvester and the ribboner. On it the stalks are dropped by the overhead conveyor track. The table is equipped with several chains, usually of agricultural hook chain. The hooks on a No. 55 chain will act as fingers to move the stalks. However, projections on the chains at intervals of from 6 to 12 inches and standing 1 to 3 inches above the feed table provide more positive movement. These may be suitable pieces of metal brazed or welded to the links, or one of the standard chain attachments. Figure 23 shows the chains without fingers just above the large crushing roll. Figure 32 shows a recent-type feed-table chain with fingers, also guide tracks to support the chains and prevent misalinement as they pass through the crushing rollers.

The chains on the feed table move the stalks toward the ribboning drums. If crushing rollers are used, the chains can be used to move the stalks through the rollers and at the same time they will act as strippers to prevent the crushed stalks from following the rollers.

FIGURE 32.—The feed table of the ribboner showing the pattern of the falling stalks, and the triangular metal pieces on the hook chain that move the stalks into the crushing rollers.

The grip chains, which hold the stalks during the processing, are near the center of the feed table. As the stalks leave the crushing rollers, they are gripped by these chains. One end of the stalks moves directly into the first of the two drums. The feed table on this side continues to move the crushed stalks, preferably up over the cone section and onto the drum. It isn't practical to carry them as far as the drum; the usual practice is to drop them on the cone section, which is equipped with serrated blades designed to move the stalks up to the drum section.

With the stalks held in the grip chains and the first end to be ribboned moving through the drum, the free ends must be kept from dragging behind. One or more feed-table chains should continue parallel to the grip chains and should carry the unribboned end of the stalks onto the second drum, or its cone section.

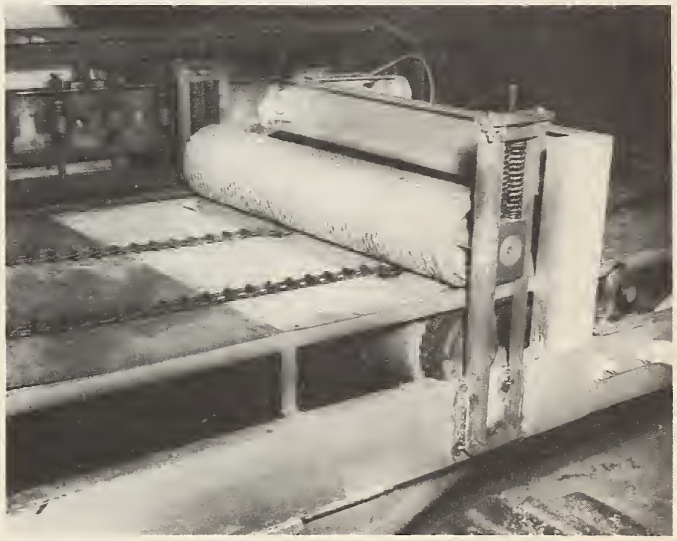

FIGURE 33.—A rope-wound crushing roller set in the feed table and operating against a three-sectioned steel roller below.

Crushing

The crushing rollers are an essential part of the ribboning process if tough woody stalks are to be ribboned efficiently. Most ramie is benefited by some degree of crushing or at least by having the woody core broken at intervals.

Crushing is not necessarily confined to rollers. However, all U.S. Department of Agriculture work has been based on rollers of one type or another. Figure 33 shows a set of rollers for crushing one end of the stalks only. The bottom roller is made of three sections of pipe with slots for the feed-table chains to pass through. The upper roller is of similar construction but wound with rope for a cushioning effect. Heavy springs

provide the pressure for crushing. Only the lower roller is driven.

Figure 34 shows a modification of these rollers with the upper roller driven, as well as the lower, and the rope replaced with spiraling metal rods. Breaking the stalks into segments is as effective as complete crushing for most types of bast fibers. Damage to the fiber layer is to be avoided, as ribboning will remove any strand that is cut. Fiber loss from cut strands and harsh mechanical action can reduce production. Crushing of the woody stalk lessens the mechanical action required in the ribboning process, permits use of lower speeds on the drums, and provides better cleaning of the ribbons.

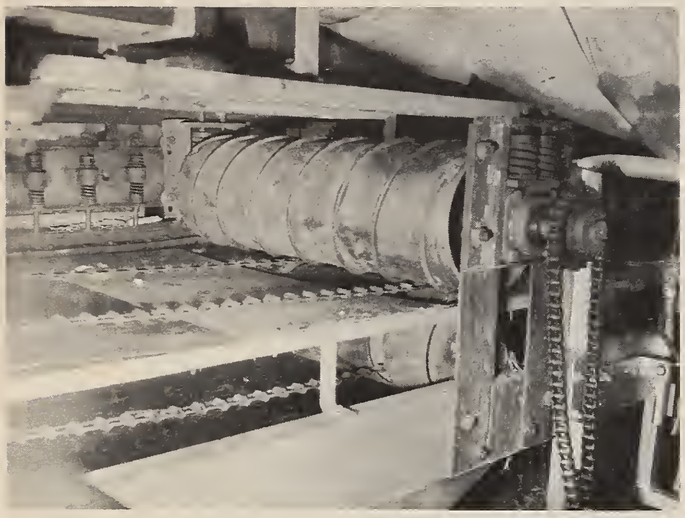

Figure 34.—A pair of short crushing rollers works one-half of the stalk between a spiral wound roller on top and a smooth roller below.

These crushing rollers crushed only the butt portion of the stalks, and while they did a fair job on a thin layer of material, they didn't provide adequate crushing on a continuous heavy mat of stalks that the ribboner should normally carry to reach maximum production. Also crushing the whole length of the stalk is desirable.

The crushing roller shown in figure 35 was installed across the feed table between the drop point from the harvester and the grip chains. The feed-table chains pass under the roller. Only one roller, made from a length of 10-inch pipe, was used. At intervals of approximately 6 inches, ½- by 1-inch flat bars were welded around the roller as rings an inch high. Welded to these rings are short pieces of ½-inch rod to move the stalks beneath the roller and across a grid set in the feed table. The grid was made from ½-inch bar stock with crosspieces between the rings on the upper roller. In operation the stalks are pressed down into the spaces in the grid by the rings on the roller, which breaks the woody core of the stalks into short sections. Behind the roller is a cross-

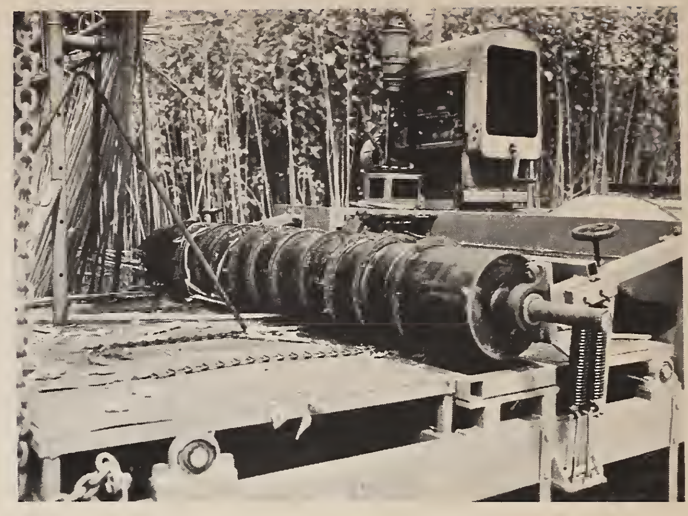

Figure 35.—Full-length crushing roller. The rings break the stalks between bars on the grid below.

piece from which extend rods bent down under the roller to keep the broken stalks from following the roller.

The grid was replaced at a later date by a second or lower roller to eliminate the friction caused by pulling the stalks across the grid. The lower roller was made from a section of 6-inch pipe with two ½- by 1-inch rings welded one on top of the other, giving a ring 2 inches high. These were spaced on each side of the matching rings on the upper roller. Both rollers were driven and the upper one was held down by two heavy springs on each end. Provision was made for takeup on the springs for pressure control and adjustable stops for depth of penetration of the upper roller rings into the space in the lower roller. This crushing system worked quite well, not only breaking the woody core of the stalks, but knocking part of it free from the ribbons. The crushing rollers are

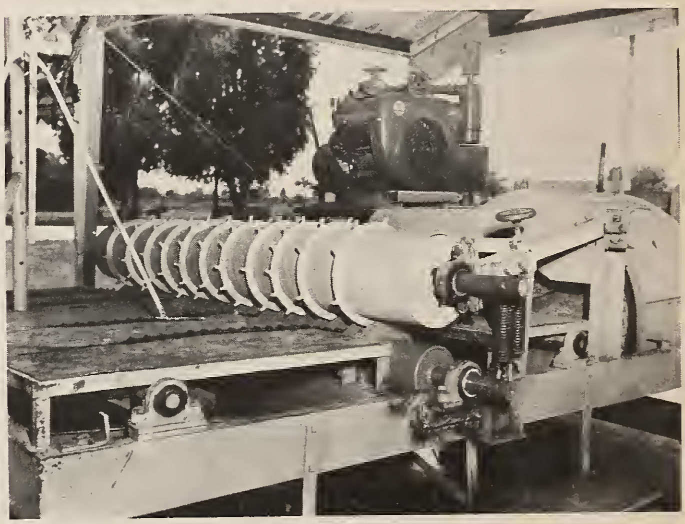

Figure 36.—The crushing rollers on the "old" ribboner. The rings on the top roller break the stalks between two rings on the lower roller.

shown in figure 36. Behind the upper roller are the strippers to keep the crushed stalks from following the fingers on the rings.

Under consideration as a crushing system is a series of chains and pads spaced 6 inches apart across the width of the feed table. These resemble the grip-chain system discussed later. Since the pads would be under spring pressure, they would crush the stalks and at the same time move them into ribboning position.

Grip Chains

The grip chains have been mentioned several times in connection with various operations of the ribboner. As used here they are what their name implies, chains for gripping the fiber. In addition, they move the crushed stalks and then the half-ribboned stalks through the various operations from the feed table to the discharge at the rear of the machine. In the several years that the U.S. Department of Agriculture ribboner has been in use, the grip chains have undergone perhaps the greatest number of modifications and experimentation. All these changes have been concerned with two basic problems: Holding the fiber in a firm grip without excessive pressure, and preventing the fiber from catching on the various parts of the system. In addition to these basic problems, is the one of transfer between the two drums.

Fiber-holding devices using ropes pulled down against the periphery of a large sheave are in general use throughout the fiber industry. However, they require too much space for field machinery and their use is limited to a relatively short drum. Many attempts have been made to design a compact gripping device suitable for small-scale operation. V-belts of several types, used in a manner similar to ropes, have had limited acceptance in spite of frequent breakage and replacement and have the same short drum limitation.

Chains, with pads of various types and materials, have been used on fiber-processing machines for some time. A system on a U.S. Department of Agriculture decorticator was adapted for the first ribboner by using a very much lighter chain with the same cast pads.

Two sets of coacting chains are used. One set carries the stalks through the first drum and the second carries them through the second drum.

Each set consists of a lower chain moving on a stationary track, and an upper chain moving under a track to which pressure may be applied in sufficient force to hold the fiber between the two chains.

Since only part of the stalk is ribboned in the first drum and the part being held by the grip chains must be processed by the second drum, the grip on the fiber must be transferred to the second set of chains, which are offset for this purpose.

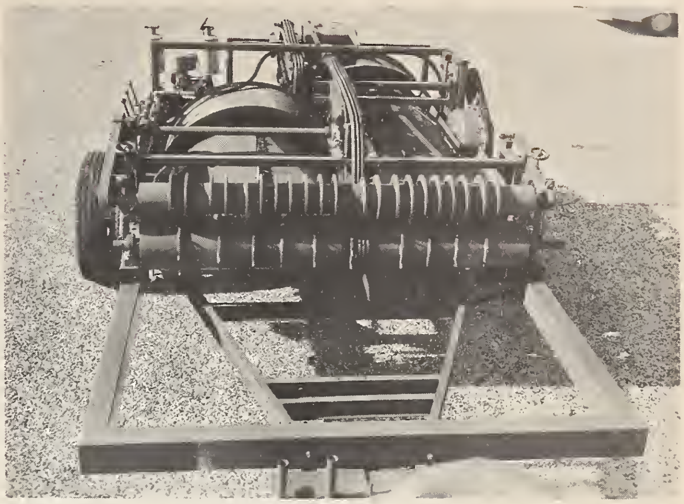

FIGURE 37.—The ribboner, less feed table and harvester, as seen from the tractor.

Figure 37 clearly shows this offset principle as applied to a recent adaptation of belting to the grip chains.

Two types of roller chain have been used on the ribboner: One is a 1½-inch extended pitch and the other a 1½-inch standard pitch. The extended pitch chain, being ¾-inch rollers connected by double-length side bars, is much lighter than the 1½-inch standard chain. The heavier chain is preferred because of its wider roller and greater stability. In both, K–1 attachments have been factory assembled at 6-inch intervals on the roller links. The attachments are used for mounting the pads which become the fiber-carrying surface of the grip chains.

The pads are of two general types. One type is grooved with the upper pad mated to the lower pad. The second type is a flat pad for carrying belting. Both types are designed to mount on the 6-inch spacing of the chain attachments.

The grooved pads are cast from shop-made patterns. Each pad is 4 inches wide and 6½ inches long. The extra half inch is required for notching at each end to avoid having a crack across the width of the pad. Figure 38 shows several pairs of pads. On the left is a set of the original cast pads showing the shape of the grooves and also the manner in which the pads are notched at the ends so that they overlap the pad ahead to form a more or less continuous surface. However, as shown by the modified set of pads in the middle of figure 38, this notching is not sufficient to prevent strands of fiber from becoming entangled. This set has a V-belt groove cast into the center of each pad. Continuous V-belts were used in this groove, not to prevent the fiber strands from getting caught in the ends of the pads, but to strip the ribbons from the pads and carry them beyond the grip chains. This had considerable

FIGURE 38.—Three types of gripping devices used on the ribboner for holding the fiber during processing.

merit but was not entirely satisfactory because of mechanical difficulties such as belt breakage, stretching, and slippage. The belts depended entirely on friction with the pad for motive power. Moisture and gums in ribboned ramie contribute to slippage as well as to embedding of the fiber in the grip pads.

The second set of grip chains presents different problems from those in the first set. The basic difference is that the first set of grip chains is holding stalks. With sufficient pressure to crush them at the grip point, and if evenly distributed, they are easily held. On the other hand, the second set of grip chains is required to hold a thin layer of wet, gummy, and somewhat slippery ribbons. It is for this reason that the ribboner is best designed to ribbon first the butt end of the stalks, and then the tip end. The butt end is more difficult to ribbon and needs greater holding, while the tip end requires less working in the drum and therefore exerts less pulling force on the grip chains. This arrangement, butts and then tips, has not always been possible on the ribboner since other considerations have made working tips and then butts necessary.

The second set of grip chains has consequently undergone several experimental changes to find improved methods of gripping ribbons. Figure 39 is an example of a modification to the rear grip chains. A flat pad 4 by 6 by 1/4 inches was bolted to the chains to replace the grooved pad. Each side of the flat piece had a metal strip welded to provide a raised edge. The fiber-holding agent on these pads, both upper and lower, was 3 3/4-inch-wide by 3/16-inch-thick rough-top neoprene belting. It formed a continuous surface to reduce catching between pads. The fiber was not held well enough by this belt to make it a satisfactory system. However, the stripping action was very satisfactory.

The pads and belts on the right in figure 38 represent the system now in use. The steel pads are similar to others tested. They have higher side pieces set onto the face to narrow the groove to 3 1/4 inches. In these grooves, 3-inch-wide rubber belts of the approximate cross section of the cast-steel pads are used to gain the advantages derived by the stripping action of continuous belts and the holding power of the cast pads. An additional cushioning effect is derived from the slight compressibility of the belt. The belts are extruded to the two shapes shown and supplied in continuous pieces, actually made up of shorter pieces vulcanized together. The manufacturer supplies a special cement and instructions for making a long splice, but this requires considerable time. With a simplified splice and a jig, the splices can be made in a short time, although 48 hours under pressure is required for setting the cement.

Limited tests indicate that these belts will be satisfactory if the manufacturer's splices stand up. Figure 31 shows how pulleys hold the belts together at the fiber transfer point. This is at the discharge side of the first drum. The ribbons drop from beneath the shield and are caught directly between the belts, move a short distance, and are then under pressure by the pads as they move past the second drum.

The sprockets used to carry the grip chains should be large enough in diameter to reduce the gap, as the pads turn, to a reasonable size. It is impossible to avoid the gap entirely, and with flat pads and rubber belts the gap is not critical. Sprockets having a pitch diameter of approximately 12 inches have been used on all U.S. Department of Agriculture ribboners and have been satisfactory. The mechanism to apply spring pressure on the upper chains requires approximately this much space for the spring box, pressure track, and return track.

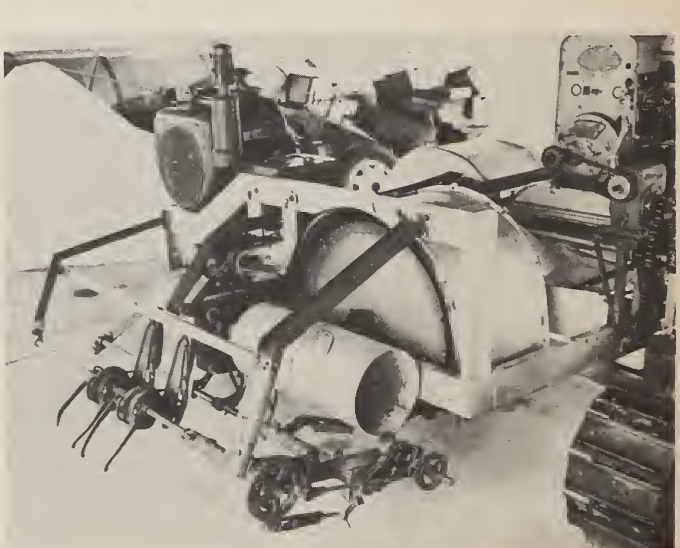

FIGURE 39.—A double-needled tying head attached to the discharge end of the field ribboner before shields and driving engine were installed.

In the center of the machine, between the two drums, the fiber is transferred from the first set of grip chains to another set of chains. The second set is offset 10 inches to the left and continues past the tips drum. The portion of the stalks ribboned in the first drum fall from the drum and are picked up by the second set of grip chains, which move the unribboned portion of the stalk into the second drum and then to the discharge point. The ribbons are not sufficiently cleaned for a few inches from the grip chains, and for this reason it is necessary to clean a small section, in the center of the stalk, in both drums. The covers over the drums are fitted with round, smooth edges that hold the ribbons close to the blades of the rotating drums. These edges can be adjusted to insure proper cleaning of the middle of the stalks.

If rubber belting is used to carry the ribbons, the sprockets at the transfer point can be carried on the same shaft. The belts can continue past the grip-chain sprockets on small idlers during the transfer process and thus keep an unbroken surface. However, with the cast pads it is necessary, at least on the lower chains, to separate the sprockets enough to permit the pads to finish their circuit of the sprocket and flatten out before they can grip the fiber again. If space permits this is also desirable on the upper chains.

Some difficulty is usually experienced at the transfer point in feeding the stalks into the second drum. If auxiliary feed-table chains are used to carry the unribboned half of the stalks to the drum, and the transfer of the fiber from one set of chains to the other is completed, a smooth flow of material will result.

The fiber gripping on the ribboner consists of two units of the same type, one serving the butts drum and the other serving the tips drum. They are overlapped at the transfer between the two drums to provide a continuous movement of the fiber stalks toward the rear or discharge end of the machine, and offset to transfer the grip on the stalks from the unworked portion to the ribboned portion coming out of the first drum. When this transfer of the gripping point is completed, the unribboned portion is ready to continue through the second drum to complete the ribboning process.

Each of these two units is made up of a lower grip chain and an upper grip chain moving together to hold and move the stalks through the drums. The lower chain rolls on a 1-inch-square cold-rolled steel track which fits the width of the roller between the side bars of the chain. The 1½-inch extended pitch chain uses a ½-inch-wide bar, and the 1½-inch standard pitch chain uses a 1-inch-wide bar. The track is several inches longer than the drum and is curved down slightly at each end and filed to a broad point at the ends to lead the chains on and off of it smoothly. The chain returns around the sprockets and under the machine. At this point an adjustable track is provided to act as a chain tightener and as a guide past framing members and to keep the chain low enough to clear the rotating drum.

While the lower grip chain operates on a rigid track, the upper grip chain is pressed against the lower one by spring pressure. Therefore, the track must be free to move—up to accommodate the entrance of the stalks, and down to apply holding power on the stalks. The chain returns over the sprockets and rides on an adjustable track, which is a tightener.

Two methods of applying spring pressure have been used. One is shown in figure 33. A section of 7-inch channel iron is rigidly attached to the frame of the ribboner above the grip-chain track. In the lower flange, holes are drilled to fit pins, which are welded at intervals to the track. Machined caps are turned to fit inside the lower end of the spring and over the end of the pin. In the upper end of the springs are similar caps, which take the adjusting bolts threaded through the top flange of the channel iron. The strap-iron pieces shown around the springs hold them in place. Later a similar box for the springs was made of flat pieces with compartments for the springs. This system had two basic faults. The welding that fastened the pins to the track could not stand the severe flexing these joints were subjected to, and wear on the single pinhole eventually led to misalinement of the grip pads.

Flexing of the pressure track is necessary for holding the fiber. A system designed to permit this is used for the new harvester-ribboner. The pressure box consists of two ¼-inch flat plates formed into a deep narrow box with ½- by 1½-inch pieces. The top and bottom pieces are bored (together) ²⁄₃₂-inch for ¾-inch cold-rolled round pins, spaced about 4 inches apart, and for ½-inch pulldown bolts between the pinholes. The bottom and endpieces are welded to the box and the top piece is made to fit inside and can be pulled down by the bolts to apply spring pressure.

One end of each pin is milled to have two flat sides leaving ½ inch in the middle. This end is ground to a 1¼-inch radius so that the end of the pin fits into a ½-inch-deep slot cut into the top of the pressure track with a ½-inch-wide by 2½-inch-diameter milling cutter. The pins should have an overall length sufficient to extend them ¼ inch above the top of the box. On the portion of the pin inside the box, a ⅝-inch flat washer, bored to ¾ inch and turned to 1⁷⁄₁₆-inch outside diameter, is welded 6 inches below the top of the box.

The springs are standard tractor parts readily available. They are 6 inches long with ¼-inch wire section, and have a ¾-inch inside diameter. Six springs are used in each of the two boxes, and they are assembled over the pin to rest on the

welded washers. The height at which the washer is to be welded is in theory a point that brings the top of the spring even with the top of the box. Then when the top piece is pulled down flush, a small amount of spring pressure is applied to the track. Further pulling down increases the pressure. The top piece must be pulled down uniformly to avoid binding the pins, which must be free to move in the holes. In practice the washers on the pins nearest the center of the box are welded slightly higher than the washers on the ends so that when the top plate is pulled down evenly there will be more pressure applied to the center of the track and less at the ends. The ends need to be free to move through a greater latitude than the middle, where the greatest holding power is required. Further adjustment, if necessary, can be supplied by adding washers under the springs.

The track is prevented from moving sidewise and from tipping by the pin in the slot. Movement in the direction of the chain travel is stopped by small pieces of metal welded across the width of the track beside three pins and on both sides of at least one pin.

Lubrication for the grip chains should be provided. Oil delivered by drip or pressure through tubing to the lower edges of the track will supply lubrication to the roller at the side bar, and is the usual recommendation. Oil supplied at one point on each chain should supply adequate lubrication by being spread along both tracks. The pins should have periodic oiling in the track slots and around the holes in the spring box.

Placement of the grip chains in relation to the circumference of the drum is important. A location at the level of the drum axis gives the maximum working length of fiber for a given drum diameter, or one-half the circumference. However, this position is disadvantageous in feeding the stalks up onto the drum. On the other hand, it presents no problem in supporting the grip chains and returning them around the sprocket since all the gripping mechanism will be outside the radius of the drum.

A location halfway up the quadrant is ideal for feeding the stalks into the drum. However, a larger diameter drum is required to compensate for the lost working distance, as only the upper half of the circumference is usable for ribboning. The grip chains will have to be supported on an offset track to keep them close to the drum, and the returning lower chain must be held low enough to clear the drum. A position at one-third of the quadrant was used on the U.S. Department of Agriculture ribboner built in 1960.

The grip chains should have a linear speed of from 75 to 90 feet per minute. A change of speed can have two effects on the operation of the ribboner. One is the length of time the ribbons are being worked by the drums and consequently the degree of ribboning that results. The other determines the density of material in the grip chain, assuming a constant rate of feeding by the harvester. Optimum grip-chain travel speed as well as the rotational speed of each of the drums depends on the type and quality of the material being ribboned. Such things as maturity, moisture content, and variety affect ribboning and determine the operating speeds of the various components. The object is to produce from the material harvested the quality of ribbons desired with as little fiber loss as possible. For this reason, each of the drums and the grip chains should have separate speed control within the limit of practical application.

Removing Ribbons

The ribbons as they leave the second drum are carried by the grip chains until they are free from the drum. A considerable quantity of material must be handled, and the final disposition to be made of the ribbons determines how this is to be done. Generally speaking, the methods are hanking, tying in bundles, and spreading on poles.

Ramie usually requires drying as the next step in the processing after ribboning. There is considerable evidence to indicate that ramie can develop its maximum strength only if dried before it is degummed. In any case it is most likely that the ribbons coming from the field machine will be taken to an area for drying or for washing and drying. For this purpose either hanking by hand or tying in bundles, either by hand or mechanically, is the preferred method of handling.

A field box of hanked ribbons is shown in the left foreground of figure 3. In this commercial operation the ribbons were made into hanks of a size convenient to handle and placed in boxes, which were then dropped to the ground to be picked up by truck. They were transported to a central plant to be decorticated or dried. Direct loading of the boxes to a trailer behind the machine would have been a more efficient operation, and probably direct loading of the hanks onto a trailer would have eliminated the need for boxes.

In some of the early work on field ribboning, a mechanical tying device was used to tie the ribbons in bundles. The basic equipment was a double-needle tying head, which had been adapted from commercial parts for use on a flax project. The needles were approximately 12 inches apart and the tying head was installed with a needle on either side of the grip chains, and located behind and below the discharge point. The additional power needed for the tying head was provided by a small gasoline engine. The tying operation was complicated by the problems of stripping the fiber from between the grip pads, and keeping the ends of the ribbons moving at the same rate as the grip chains.

FIGURE 40.—An early model of the harvester-ribboner with the double-needled tying head in operation.

To improve the stripping, the grip pads were replaced by rough-top belting, mentioned previously. A wide canvas belt was added at one side of the gripping belts to carry one end of the ribbons. It was driven by a 14-inch sheet-metal drum on one side of the lower grip-belt sprocket, and a similar drum on the other side of the grip pads was used to roll the other end of the ribbons into the tying head as they came out of the second drum.

Figure 39 shows the tying head under construction, and figure 40 is a field view of the equipment in use. Since the rough-top belt did not have sufficient holding power for the ribbons in the ribboning drum, no completely satisfactory testing of the bundle-tying equipment was possible. The present rubber gripping belt may lead to further work on tying, either on an entirely automatic basis or with hand loading of a semiautomatic tying head.

Hanking the ribbons would almost certainly be a hand process since they must be separated into handfuls, looped, and twisted to hold their shape. Some mechanization could be used in handling and loading the hanks.

Another method of handling the ribbons is by use of 2- by 2-inch poles of suitable length (fig. 27). The ribbons are removed from the grip pads and spread on a pole held in a slot on the machine. The pole is replaced when 100 to 200 pounds of ribbons have accumulated. This system has particular merit if the ribbons are to be washed before drying. Hanks are preferred if the fiber is to be spread on a conveyor belt. They are also preferred if the fiber is to be placed in a centrifuge to remove excess moisture before drying. Drying directly on the poles would be possible although a special drying technique would have to be developed for this method.

Power Requirements

Field harvester-ribboners require considerable power. It varies widely, depending on speed range, direction of rotation, axes orientation, and location. To avoid complicated drives, two separate power sources are used on the ribboner part of the machine. Additional power is derived as needed from the towing tractor through the power takeoff and the hydraulic system. The ribboner requires drives in two axes, the drums parallel to the direction of travel and the feed table and grip chains at 90°. One engine drives the two drums, which run at approximately the same speed. A second engine provides power for the remaining drives, all of which require a gear reduction to relatively slow speeds.

An early model of the tractor-mounted harvester drove the overhead gathering equipment through a chain drive from the wheel of the tractor as a means of timing the gathering chains to groundspeed. This resulted in a rather clumsy drive requiring a disengage clutch. A drive from the belt pulley replaced this first drive, and later the entire harvester was mounted on the ribboner and driven from the power takeoff through a universal joint and jackshaft. The harvester requires a gear reduction and also correlation of the tractor engine speed, transmission ratio, and the gathering chains to arrive at a suitable groundspeed matched by a gathering speed only slightly greater than the groundspeed. This is not difficult except that only one gear speed on the tractor may be used without a change in the gear train to the harvester. The tractor should be operated at an engine speed that provides adequate power. For experimental purposes we use a tractor equipped with a low-low gear that gives a groundspeed of 1.7 m.p.h. at full throttle.

The tractor, in addition to towing the ribboner and driving the gathering mechanism, was used to supply three other power needs of the harvester. The power takeoff drove the gear reducer for the gathering chains through a jackshaft. From this shaft the cutter-bar mower and, later, a hydraulic drive for the rotary stalk cutter were driven. In addition, the shaft was connected through an overriding clutch to a flexible shaft which turned the topping saw. The overriding clutch was a hinged shaft mechanically linked by a small steel cable to the tractor's clutch pedal to prevent the centrifugal force of the high-speed topping saw from unwinding the flexible shaft when the clutch was disengaged. The standard hydraulic system on the tractor was used to operate a cylinder for raising and lowering the harvester.

The drums on the ribboner rotate in opposite directions. If both are to be driven from one engine, one will be driven direct and the other through a sprocket on the back side of the driving chain, either directly or through a jackshaft. A spur-gear drive was used until 1960 when a new ribboner was built. However, neither drive provides for variation of individual drum speed to meet field conditions.

The grip chains and crushing rollers at first were driven through an angled gear reducer from the same drive as the drums with only one engine. When the need for more power became apparent, another engine was added to drive the grip chains. Later the angled gear reducer was replaced with a double reduction torque drive to handle heavier crushing rollers.

The ribboner built in 1960 incorporated several basic changes in the use of power. A 36-hp. air-cooled engine was installed beneath the feed table to drive the second (tips) drum. This engine has a 3.6:1 gear reduction clutch and drives the drum through a double-strand roller chain. The optimum drum speed is designed to operate at less than full engine speed to allow for additional drum speed when needed.

A new-type 75-hp. air-cooled engine is used for all remaining drives on the ribboner and harvester except gathering chains on the harvester, which are driven from the power takeoff, and the hydraulic cylinder for raising the harvester, which is driven from the hydraulic system of the tractor through a remote-control valve on the ribboner.

This engine has a 3.6 : 1 gear reduction clutch from which a 13 : 16 V-belt reduction drive to a jackshaft is taken. An extra groove on the clutch pulley drives a high-speed hydraulic vane pump, which supplies hydraulic power to a hydraulic gear motor directly mounted to the topping saw on the harvester. Figure 17 shows how this saw is mounted. The two hoses are looped and attached to the connections on the main frame of the ribboner. This arrangement allows for the movement of the harvester.

The jackshaft drives the first (butts) drum through a double-strand roller chain and also drives two hydraulic pumps through chain drives. The jackshaft and hydraulic pumps are all beneath and behind the engine.

The hydraulic system consists of several motors widely dispersed, but with their control valves and pumps closely grouped near the engine which drives them. This makes it possible to use very short hose connections between supply manifold and pumps, and between pumps and control valves. The system is designed to eliminate long hose lines and metal tubing is used where possible.

To avoid the use of a large reservoir for hydraulic fluid, parts of the main frame were built not only to function as a reservoir for an adequate quantity of fluid, but also to serve where possible as supply and return lines. The main frame is constructed of 4- by 6-inch rectangular tubing including two crossmembers of the same material. One of these is welded to the frame at each end. Near one end a heavy block, bored and tapped for four 1-inch hydraulic hose connections, is welded to the face over four 1½-inch holes. Near the other end a similar block has a 1½-inch pipe tap and is connected to a hydraulic filter submerged in a small supply tank. Three of the hose connections lead to the hydraulic pumps; the fourth is plugged for future use. This section of the frame then becomes a supply manifold with all hose connections less than 3 feet in length.

The other crossmember and part of the main frame are connected to each other and through a return pipe to the supply tank. This part of the frame acts as a return manifold. Pipe taps are supplied close to all motors so that only short hoses are needed for return lines. The control valves are grouped and mounted on sections of 2- by 2-inch square tubing. These sections also serve as return lines for the valves as the tubes are welded over holes in the frame and the valves are equipped with bottom outlet ports for direct tank mounting. Figure 41 shows the three valves with supply lines coming in from the left. Lines to the motors are the two pipes to the right, and a hose connection to a pipe that supplies the motor on the far side of the machine. An operator's seat will be over the wheels. The lever is a remote clutch control for the engine driving the tips drum.

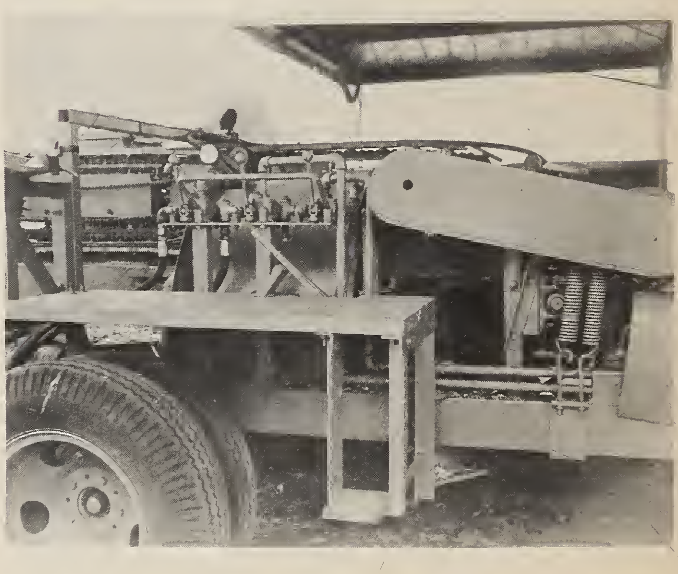

FIGURE 41.—The control center on the ribboner. Engine clutches and hydraulic valve are within reach of the operator.

The topping saw motor operates at 2,000 r.p.m. and is supplied by a vane-type hydraulic pump. The rotary cutter operates at 500 r.p.m. and is supplied by a gear-type hydraulic pump. It uses a V-belt drive between gear motor and rotary cutter. This will be converted to a direct mounting when an adjustable cutter is installed. A modified cutter-bar mower may be operated with this motor where field conditions require this type cutter.

The remaining drive is more complex as it requires high power at a very slow rotary speed. It is driven by a hydraulic gear pump to a gear motor, which drives a 14:1 double reduction shaft-mounted drive. This in turn drives the grip chains through a 2:1 roller chain reduction. Also driven by this drive are the crushing rolls and the feed-table chains, all of which must operate at very close to the same linear speed.

Capacity

The harvester-ribboner, in various forms and models, has been used to harvest a small planting of ramie in the Florida Everglades for several years. From data collected over several seasons, two sets will illustrate performance characteristics of the ribboner. Both are based on June harvests. In 1959 the earlier model of the machine was used and in 1961 the present ribboner.

In 1959 on the basis of approximately one-third acre on which time measurements and ribbon weights were taken, the following data were interpolated: The machine harvested and ribboned approximately one-half acre per hour at a groundspeed of 1.7 m.p.h. An acre of average ramie produced 3,750 pounds of wet ribbons or 846 pounds of dried ribbons. Samples of these ribbons, degummed in an open batch cook, yielded 517 pounds of finished ramie fiber per acre with a degumming loss of 38.8 percent. In the same field of ramie in 1961, with a new machine, a yield of 811 pounds of dry ribbons per acre produced 556 pounds of degummed fiber with a degumming loss of 31.4 percent. Groundspeed for this test was also 1.7 m.p.h.

In 1959 the ribboner was operating at near capacity with both drums driven by a 36-hp. engine. No increase in groundspeed was possible without additional engine capacity. In 1961 the ribboner was equipped with a 36-hp. engine on one drum and a 75-hp. engine on the other. The larger engine also powered three hydraulic drives. This was more power than needed at a groundspeed of 1.7 m.p.h. With this additional power the groundspeed was increased to 2.6 m.p.h. and better ribboning resulted because of a heavier mat of material going through the machine. At this speed approximately nine-tenths acre per hour was harvested.

SUMMARY AND CONCLUSIONS

Ramie, a bast fiber, has been known and produced since historical times as a superior textile fiber.

Ramie fibers consist of the fibrous inner bark of stems of *Boehmeria nivea*. The fiber layer must first be removed from the woody stem and then processed to remove certain of the gums and pectins which cement the individual fibers together.

Ramie is planted by root cuttings which soon cover the ground with a solid mat of vegetation from which several cuttings per year can be made for 8 to 12 years.

Many machines for processing ramie have been built and many of those now in use are described in this publication. However, the principal machine discussed is the harvester-ribboner developed by the U.S. Department of Agriculture.

A small combined harvesting-processing machine has a definite place in the production of long vegetable fibers. The U.S. Department of Agriculture harvester-ribboner was developed first as a stationary ribboner to produce fiber from stalks hauled from the field. Later it was mounted on wheels and moved to the field as a mobile ribboner and finally it was equipped with a harvester unit so that it could be moved through the field, cutting the stalks and ribboning in one operation.

The standing stalks in the field must be divided into those to be cut and those to be left standing for the next pass of the harvester-ribboner. Correct division of the stalks is fairly simple when done near the ground. The divider must lift bent stalks, separate tangled ones, and direct them toward the gathering point.

When the stalks are in position the two chains separate over adjustable sprockets and the stalks fall to the feed table in position to enter the ribboning drums.

The ribboner consists of two rotating drums, a set of chains or belts for holding and moving the stalks and, when required, crushing rollers. The drums rotate in opposite directions, each ribboning half the length of the stalks.

The stalks are fed up over the top of the drums, and under a cover. Scalloped blades on the face of the drum break up and comb out the woody core and other material. The drums are 42 inches in diameter and turn between 200 and 300 r.p.m. The stalks move through the machine at 75 to 90 feet per minute.

The overhead harvester drops the stalks across the feed table, from which they are moved first through crushing rollers and then through the ribboning drums. Several hook chains with vertical fingers move the harvested material until the grip belts take over after the crushing and then only

those chains on the outer edges continue for the purpose of moving the stalks into the drums.

The crushing rollers are essential for efficient ribboning of tough woody stalks.

Two sets of grip chains are provided. The first set carry the stalks through the butts drums and then release the stalks to a second set of chains which are offset to take a new grip on the ribboned half of the stalks and then move the unribboned half of the stalks through the tips drum. The belts continue beyond the chains to move the finished ribbons to the discharge point.

The ribbons as they leave the ribboner may be handled in several ways. Hanking, tying in bundles, and spreading on poles are the usual methods. Tying in a bundle of suitable size could be done mechanically and would be a convenient method of handling since mechanical drying usually follows ribboning.

The power requirement of a field harvester-ribboner is considerable. Unless the ribboner is self-propelled, the towing tractor can furnish power for the overhead harvester as this must be synchronized with groundspeed. Also the tractor, if equipped with a hydraulic system, can supply oil pressure for the cylinders which adjust the operating heights of the harvester and rotary cutter.

An engine of 75 horsepower may be used to drive the drums and other parts of the ribboner. Hydraulic pumps and motors can be operated from this engine to supply power for the grip chains, crushing rollers, rotary cutter, and topping saw. One or both drums could also be driven by hydraulic power to avoid drives complicated by reverse rotation. Separate control valves provide convenient central operation.

To avoid the need for a large reservoir for hydraulic fluid, parts of the main frame were built to function as supply and return manifolds. Each hydraulic motor and each bypass valve connect directly to the nearest point in the main frame, a 4- by 6-inch rectangular tube, through which the oil flows to a small supply tank. The large surface area of the frame supplies sufficient cooling to permit a considerable reduction in oil volume.

The U.S. Department of Agriculture harvester-ribboner has proved successful in the production of ramie fiber. Field production of ribbons followed by degumming has produced finished fiber equal to degummed decorticated fiber. The degumming loss with ribbons may be 6 or 7 percent greater than with decorticated fiber; however, the total loss from green stalk to degummed fiber will be about equal. With ample power and at a groundspeed of 2.6 miles per hour, the machine will cut and ribbon at the rate of 0.75 to 1.00 acre per hour.

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